**DOCUMENT RESUME**

ED 167 826 SE 026 880

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| AUTHOR | Suydam, Marilyn N., Comp. |
| TITLE | Reference Bulletins from the Calculator Information Center. |
| INSTITUTION | Calculator Information Center, Columbus, Ohio. |
| SPONS AGENCY | National Inst. of Education (DHEW), Washington, D.C. |
| PUB DATE | Apr 79 |
| CONTRACT | 400-77-0030 |
| NOTE | 90p.; Contains occasional light and broken type |
| EDRS PRICE | MF-$0.83 HC-$4.67 Plus Postage. |
| DESCRIPTORS | *Booklists; *Calculation; Elementary Secondary Education; *Instruction; Literature Reviews; *Mathematics Education; Postsecondary Education; *Research Reviews (Publications) |
| IDENTIFIERS | *Calculators |

ABSTRACT

These 19 bulletins list references on the uses of calculators pertinent to education. They were published at intervals to provide teachers and other interested persons with sources of information about calculator activities and research findings. The bulletins focus on several categories of references: (1) articles on instruction with hand-held calculators; (2) books on calculator applications; (3) research on hand-held calculators; (4) references on calculators at the post-secondary level; (5) references on desk calculators; (6) articles on the pros and cons of using hand-held calculators; and (7) articles on selecting a calculator. Most of the bulletins contain annotations; several include an introductory synthesis. (Author)

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# Reference Bulletins from the Calculator Information Center

-ED167426

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compiled by

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TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

April 1979

These bulletins list references on the uses of calculators pertinent to education. They were published at intervals to provide teachers and other interested persons with sources of information about calculator activities and research findings.

The first six bulletins developed for the Center are not included; references on these bulletins are listed on succeeding bulletins. The bulletins focus on several categories of references:

**Articles on Instruction with Hand-Held Calculators (K-12)**
Bulletins 7, 14, 15, 19, and 23

**Books on Calculator Applications (K-12)**
Bulletins 8, 14, 16, 20, and 23

**Research on Hand-Held Calculators (K-12)**
Bulletins 9, 14, 17, 21, and 23

**References on Calculators at the Post-Secondary Level**
Bulletins 13, 18, 22, and 24

**References on Desk Calculators**
Bulletin 10

**Articles on Pros and Cons of Using Hand-Held Calculators**
Bulletin 11

**Articles on Selecting a Calculator**
Bulletin 12

Most of the bulletins contain annotations; several include introductory syntheses.

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* Director, Calculator Information Center, since its origination in March 1977. Funded by the National Institute of Education, Contract No. 400-77-0030.

SE 026 880

CALCULATOR INFORMATION CENTER

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Instruction with Hand-Held Calculators, K-12

Bulletin No. 7
August 1977

Articles

Albrecht, Bob. Calculators for Beginners. Calculators/Computers 1: 21-36; May 1977.

This is the first in a serialization of a "self-teaching" student workbook about simple four-function calculators and elementary computer programming. Basic addition, subtraction, and multiplication are covered, some computer-like notation for writing programs is introduced, and directions are given for playing NIM.

Bahe, L. W. Finding Logarithms and Antilogarithms with a Simple Calculator. School Science and Mathematics 74: 221-224; March 1974.

A method of finding logarithmic values using a simple matrix and a four-function calculator is provided.

Bell, Max S. Calculators in Elementary Schools? Some Tentative Guidelines and Questions Based on Classroom Experience. Arithmetic Teacher 23: 502-509; November 1976.

Student reactions to calculators, some pedagogical questions that may need further investigation, and some classroom management suggestions are discussed.

Bitter, Gary. The Calculator and the Curriculum. Teacher 94: 64-67; February 1977.

Using the calculator for interdisciplinary projects is discussed, with a list of 15 topics and activities in which calculators can be used. Six interdisciplinary activities are described in detail: for primary grades--car counting, planning and planting a garden; for intermediate grades--population growth, organizing a recycling program; for upper grades--school election prediction, pollution analysis.

Boyle, Patrick J. Calculator Charades. Mathematics Teacher 69: 281-282; April 1976.

Computations yielding results which can be read as words or phrases are presented.

Braun, Alexander E. Eulogy for a Slide Rule. Science Digest 79: 65-67; February 1977.

The "passing" of slide rules is humorously decried.

Bruni, James V. and Silverman, Helene J. Let's Do It! Taking Advantage of the Hand Calculator. Arithmetic Teacher 23: 494-501; November 1976.

Activities are suggested which focus on developing skills for using the calculator, exploring basic arithmetic operations, understanding algorithms, mental calculation and estimation, and problem solving.

Champion, R. R. Talking Calculator Used with Blind Youth. Education of the Visually Handicapped 8: 102-106; Winter 1976-77.

Ways of using the calculator with the blind are discussed.

Cohen, David B. Another Way of Finding Prime Numbers. Mathematics Teacher 69: 398-400; May 1976.

A method of finding large primes using calculators or computers is presented.

Eimer, Rebecca A. Cube Roots on a Calculator. Mathematics Teacher 70: 175; February 1977.

An algorithm is given for using a calculator to compute the cube root of any real number.

Elder, Mary C. Mini-Calculators in the Classroom. Contemporary Education 47: 42-43; Fall 1975.

Student discoveries about numbers and operations, stemming from the use of a calculator, are described.

Field, Roger. Endangered Species: The Slide Rule. Science Digest 81: 68-69; March 1977.

The calculator's effect on sales of slide rules is briefly discussed.

Friesen, Charles D. Check Your Calculator Computations. Arithmetic Teacher 23: 660; December 1976.

A number-word puzzle to be solved on the calculator is presented.

Gardner, Martin. Mathematical Games: Fun and Serious Business with the Small Electronic Calculator. Scientific American 235: 126-129; July 1976.

A cryptarithm, activities involving limits, a keyboard game, and several number tricks to be done on a calculator are described and explained.

Gawronski, Jane Donnelly and Coblentz, Dwight. Calculators and the Mathematics Curriculum. Arithmetic Teacher 23: 510-512; November 1976.

Use of the calculator is considered from a functional view and from a pedagogical view.

Gibb, E. Glenadine. Calculators in the Classroom. Today's Education 64: 42-44; November-December 1975.

Ways in which the calculator can be used are discussed.

Greenwood, Jay. A Product of Our Times. Mathematics Teacher 70: 234-238; March 1977.

Activities are described in which the calculator is used in a discovery learning situation for exploring number patterns in multiplication exercises.

Gregory, John W. Use the Calculator for Drill. Instructor 86: 104-105; April 1977.

Activities are described which feature the use of a calculator's constant key in drills on basic facts.

Guthrie, Larry F. and Wiles, Clyde A. Why Not Have a Calculator Tournament? Arithmetic Teacher 23: 554-558; November 1976.

Steps in organizing a calculator tournament among schools are presented, with sample problems given.

Hiatt, Art. A Geometry Problem for Hand-Held Calculators or Computers. Calculators/Computers 1: 37-38; May 1977.

A mathematical inquiry method (making and organizing observations, generalizing, specializing, inventing symbolism, and proving conjectures) and the calculator's role as an important tool for this process are discussed. An example is given in which the concept of area of a circle can be investigated, with a worksheet.

Hoffman, Ruth I. Don't Knock the Small Calculator -- Use It! Instructor 85: 149-150; August/September 1975.

Several examples of using calculators to explore mathematical ideas are given.

Hopkins, Edwin E. A Modest Proposal Concerning the Use of Hand Calculators in Schools. Arithmetic Teacher 23: 657-659; December 1976. (Reprinted in Education Digest 42: 44-45; February 1977.)

A proposal that the fullest possible use of calculators be made at all grade levels is discussed.

Huff, D. Teach Your Pocket Calculator New Tricks to Make Life Simpler. Popular Science 205: 96-98; December 1974.

Interesting things to do with a calculator are presented.

Huff, Darrell. How to have Fun with Your Pocket Calculator. Popular Science 208: 90-91, 152; February 1976.

Activities and games for the calculator are presented.

Immerzeel, George. It's 1986 and Every Student Has a Calculator. Instructor 85: 46-51, 148; April 1976.

Topics discussed include algorithms, calculator problems, homework, problem solving, mental arithmetic, and designing tests for use with calculators. Specific problems for primary, middle, and upper elementary grades are also included.

Immerzeel, George. It's In Your Hands. Arithmetic Teacher 23: 493; November 1976.

Teachers are reminded of their responsibility for deciding how best to use the calculator in their classrooms.

Johnsonbaugh, Richard. Applications of Calculators and Computers to Limits. Mathematics Teacher 69: 60-65; January 1976. (For Reader Reactions, see Mathematics Teacher 69: 436-438; October 1976.)

Computing numbers approaching a limit is discussed, with a convergence theorem and several examples.

Judd, Wallace. Rx for Classroom Math Blahs: A New Case for the Calculator. Learning 3: 41-48; March 1975.

As calculators are increasingly used, drill will be de-emphasized in favor of problem-solving activities. Considerations for selecting calculators and selected games for use with calculators are described.

Judd, Wallace. Instructional Games with Calculators. Arithmetic Teacher 23: 516-518; November 1976.

Seven games are presented, with the mathematical concepts involved, the objective, the number of players needed, the rules, and variations for different grade levels.

Kahn, Henry F. The Calculator a Calendar? Arithmetic Teacher 23: 651-653; December 1976.

A method for using the calculator to determine the day of the week on which any given date falls is explained.

Koller, Elayne Z. and Mulhern, Thomas J. Use of a Pocket Calculator to Train Arithmetic Skills with Trainable Adolescents. Journal for Special Educators of the Mentally Retarded 13: 134-138; Winter 1977.

A rationale for the use of calculators with trainable adolescents is presented, with a description of a pilot study assessing an approach to teaching addition and subtraction to six moderately retarded students. A detailed presentation of the program used is included.

Kremer, Ronald. The Bicentennial Calculator. Mathematics Teacher 69: 463; October 1976.

An addition activity based on the calculator keyboard is described.

Maor, Eli. The Pocket Calculator as a Teaching Aid. Mathematics Teacher 69: 471-475; October 1976. (For Reader Reactions, see Mathematics Teacher 70: 291; April 1977.

Suggestions are given for using calculators for computations too trivial for computer processing but too time-consuming for hand calculation. Several examples from arithmetic, algebra, and calculus are included.

McWhorter, Eugene W. The Small Electronic Calculator. Scientific American 234: 88-98; March 1976.

Details are given concerning the inner workings of the electronic calculator.

Meconi, L. J. Using the Hand-Held Calculator in Industrial Education. Industrial Education 66: 22-23; February 1977.

Several examples of elementary technical problems in which students can use calculators are given: finding average monthly sales, dealing with lengths and with circuits, figuring percents, and converting from English to metric units.

Mims, F. Calculators: From the Abacus to the Electronic Calculator. Radio-Electronics 43: 51-54; December 1972.

The development of calculating machines is traced.

Moursund, David. Calculators in the Elementary School. Calculators/Computers 1: 7-10; May 1977.

Using the calculator as an aid in problem-solving situations is discussed, with suggestions for the classroom. Goals for teaching about calculators are stated, including mechanical aspects, capabilities, limitations, errors, problem solving, and when to use calculators.

Ockenga, Earl. Calculator Ideas for the Junior High Classroom. Arithmetic Teacher 23: 519-522: November 1976.

Activities and games for computation and estimation, measurement and geometry, functions, and problem solving and applications are described.

Oglesby, Mac. "Hill", "Hurkle". Calculators/Computers 1: 42-47; May 1977.

Directions for two calculator games are given. One can be played on either a four-function or a programmable calculator, the other only on a programmable calculator. Flowcharts and programming steps are provided.

Osborne, J. M. The Pocket Calculator in School Physics. Physics Education 9: 414-419; September 1974.

The significance of the simple type of calculator as a tool in the classroom is discussed, as well as the contribution of the more sophisticaled type.

Peters, William T. The HP-25 as a Digital Clock and Timer. Popular Electronics 11: 57-58; August 1977.

How to program an HP-25 calculator to serve as a clock/timer with display in hours, minutes, and seconds is described.

Pitcairn, Cameron C. and Baker, Gregory L. The Rocket Game. Physics Teacher 12: 427-429; October 1974.

A program for a programmable calculator is provided which simulates the problems of rocket propulsion, hovering, and soft landing.

Pollak, Henry O. Hand-Held Calculators and Potential Redesign of the School Mathematics Curriculum. Mathematics Teacher 70: 293-296; April 1977.

The content and teaching of secondary-school mathematics in the calculator era are discussed.

Riden, Chuck. Less Than Ten on a Calculator. School Science and Mathematics 75: 529-531; October 1975.

A method to check addition and subtraction in any number base less than ten, using a simple adding machine or a calculator, is given.

Rogers, James T. 10 Games You Can Play with a Pocket Calculator. Science Digest 77: 42-45; May 1975. (See also: Rogers, James T. Seven Pocket Calculator Games. Creative Computing 2: 19; January-February 1976.)

Brief directions for games and "tricks" are presented, with the mathematical rationale behind the "tricks" not explained.

Stolovich, Harold. A Pocket Calculator Never Loses Patience. Audiovisual Instruction 21: 19-20; December 1976.

Seven advantages of using a calculator in teaching mathematics to handicapped learners are identified. The use of the calculator as a tool for discovery, for drill and practice, and for motivation is discussed.

Stultz, Lowell. Electronic Calculators in the Classroom. Arithmetic Teacher 22: 135-138; February 1975. (For Reader Dialogue, see Arithmetic Teacher 22: 658-660; December 1975.)

Several applications of calculators at various elementary grade levels are suggested, with some punch/display sequences illustrated.

Sullivan, John J. Using Hand-Held Calculators in Sixth-grade Classes. Arithmetic Teacher 23: 551-552; November 1976.

Classroom use of calculators is described, including a brief discussion of ways in which the use of the calculator can enrich, supplement, support, and motivate the regular program.

Vail, Roy. Programmable Calculators in Biology Classes. American Biology Teacher 36: 496-498; November 1974.

Some uses of calculators in biology classes are described; for example, charting exponential population curves, evolution by natural selection, and random genetic drift.

Wilderman, Ann. Math Skills for Survival in the Real World. Teacher 94: 68-70; February 1977.

Six mathematics units for middle and upper elementary grades are described: banking, transportion, taxes, budgeting, shopping, and pricing and advertising. For each unit, mathematical skills and practical applications are identified, vocabulary is listed, and a series of student learning activities, some using calculators, is suggested.

Woodburn, Douglas. Can You Predict the Repetend? Mathematics Teacher 69: 675-678; December 1976.

Worksheets are provided for an activity involving the use of the calculator in discovering patterns when a number is divided by 9, 99, and 999.

Yarbrough, L. D. The Keyboard Game. Creative Computing 2: 20-21; January-February 1976.

A two-person game to be played on a pocket calculator is described and the winning strategy discussed.

How to Program Calculators for Fun and Games. Popular Electronics 11: 39-46; June 1977.

A collection of six games for the programmable calculator are presented: Battle the Dive Bomber, Football, Blackjack, Space Flight, Biorhythm Forecast, and Test Your ESP. Goals and rules are described, with programs (for the HP-25).

Minicalculators in Schools. Arithmetic Teacher 23: 72-74; January 1976. Mathematics Teacher 69: 92-94; January 1976.

This report from the NCTM Instructional Affairs Committee presents nine justifications for using the hand-held calculator in classrooms, with some specific examples of curricular applications.

Non-Commercial Publications

Beisse, Karen; Brougher, Janet; and Moursund, David. Calculators in the Elementary School. Portland, Oregon: Oregon Council for Computer Education, May 1976. [Available from OCCE, 4015 S.W. Canyon Road, Portland OR 97221 -- $2.00]

The role of the calculator in the elementary-school classroom is briefly discussed. Suggestions for calculator activities are given, with informal evaluations of some.

Bell, Max; Esty, Edward; Payne, Joseph N.; and Suydam, Marilyn N. Hand-held Calculators: Past, Present, and Future. In Organizing for Mathematics Instruction (edited by F. Joe Crosswhite). 1977 NCTM Yearbook. Reston, Virginia: National Council of Teachers of Mathematics, 1977. Pp. 224-240. [Available from NCTM, 1906 Association Drive, Reston, VA 22091 -- $9.00 for members, $10.00 for non-members]

An overview is provided for each of four reports dealing in whole or in part with calculators (the NACOME report, the Euclid Conference report, the status study report to the NSF on calculators in pre-college education, and the report on the Conference on Needed Research and Development on Hand-Held Calculators). Activities in several school systems are also cited.

Caravella, Joseph R. Minicalculators in the Classroom. Washington: National Education Association, 1977. [Available from NEA, 1201 16th St., N.W., Washington, D.C. 20036 -- Stock Number 1812-5-00, $2.50 paper, $5.25 cloth]

Uses and implications of use, research, selection guidelines, and activities are discussed, with the activities keyed to the various functions of the calculator.

Suydam, Marilyn N. Electronic Hand Calculators: The Implications for Pre-College Education. Final Report, Grant No. EPP 75-16157, National Science Foundation, February 1976. [Available from ERIC Document Reproduction Service, Box 190, Arlington, VA 22210 -- 50-page body, ED 127 206 (microfiche, $0.83; hardcopy, $2.06, plus postage); full report, ED 127 205 (microfiche, $0.83; hardcopy, $20.75, plus postage)

The range of beliefs and opinions about the impact of the calculator on pre-college educational practice is reported, with information derived from a literature search and from a surveys of several groups. Appendices in the full report discuss plausible instances with which to use calculators, criteria for redesigning the curriculum, needed research, and perspectives for curriculum revision.

Vitale, Marie (editor). The Hand Calculator as a Problem Solving Device. Missouri Council of Teachers of Mathematics, Fall 1977 (in press). [Available from M. Vitale, 1431 Barger Place, St. Louis, MO 63117 -- $4.00]

This document will contain 20 articles on different ways a calculator can be used in a classroom.

Calculator Cookery. Minneapolis Public Schools, East Area Curriculum Office, 1977. ERIC: SE 022 845, 87 pages. [To be available from EDRS late in 1977.]

Worksheets were designed for use with low-achieving ninth and tenth graders; they also seem appropriate for seventh and eighth graders. Activities are included on: introduction to the calculator, games, exploring algorithms, pattern search, estimation and reinforcement of basic computation, consumer applications, and societal applications. Notes for teachers are included with each lesson.

The Hand-Held Calculator. Iowa Council of Teachers of Mathematics, 1976. [Available from Ann Robinson, ICTM, 2712 Cedar Heights Drive, Cedar Falls, Iowa 50613 -- $2.00]

Activities appropriate for the middle school are presented, most as worksheets.

High School Activities for the Calculator. Iowa Council of Teachers of Mathematics, 1977. [Available from Ann Robinson, address above -- $2.50]

Calculator activities are organized under the following categories: algebra, advanced algebra, general mathematics, geometry, junior high, probability, trigonometry, and miscellaneous.

Minicalculator Information Resources. Reston, Virginia: National Council of Teachers of Mathematics.

This free resource list cites articles, books, newsletters, and media, plus information on calculator models appropriate for school use.

Report of the Conference on Needed Research and Development on Hand-Held Calculators in School Mathematics. National Institute of Education and National Science Foundation, 1977.
[Available from E. Esty, National Institute of Education, Mail Stop 7, 1200 19th St., N.W., Washington, D.C. 20208 -- also ERIC: SE 022 565]

Results of the conference, intended to provide a well-defined framework for future research and development efforts, are reported. Twenty-one recommendations covering the development of an information base, curriculum development, research and evaluation, teacher education, and dissemination are discussed.

Uses of the Calculator in School Mathematics, K-12. Monograph No. 12, Michigan Council of Teachers of Mathematics, March 1977.
[Available from MCTM, Box 16124, Lansing, MI 48902 -- $1.50]

Part I considers desirable features of calculators for classroom use, basic assumptions, and curriculum concerns. Part II is a collection of activities for grades K-3, 4-8, and 9-12, with a bibliography.

Using the Mini-Calculator to Teach Mathematics. Philadelphia: Curriculum Office, Instructional Services, The School District of Philadelphia, 1977.
[Available from Dr. Alexander Shevlin, Stevens Administrative Center, 13th and Spring Garden Streets, Philadelphia, PA 19123 -- Publication #547870, $3.00]

Calculator activities are presented on place value, rounding off numbers an estimating answers, whole numbers, decimal fractions, common fractions, number patterns, powers and roots, algebra, geometry, and advanced topics. Other sections discuss calculator selection, types of use, the keyboard, displays and problems.

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August 1977: Revision of Reference Bulletin No. 1, April 1977.

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Books on Calculator Applications

Bulletin No. 8
August 1977

Ahl, David H. (editor). The Best of Creative Computing, Vol. 1. Vol. 2. Morristown, New Jersey: Creative Computing Press, 197_.

Auten, James H. and Webb, D.G. The Crash-Speed Calculator. Springfield, Illinois: Charles C. Thomas, 1972.

Beakly, George C. and Leach, H. W. The Slide Rule, Electronic Hand Calculator, and Metrification in Problem Solving (Third edition). New York: Macmillan, 1975.

Benrey, Ronald. How to Get the Most Out of Your Low-Cost Electronic Calculator. Rochelle Park, New Jersey: Hayden, 1976.

Bitter, Gary G. and Metos, Thomas H. Exploring with Pocket Calculators. New York New York: Julian Messner, Inc. (Distributed by Simon & Schuster, Inc.), 1977.

Buckwalter, L. 100 Ways to Use Your Pocket Calculator. Greenwich, Connecticut: Fawcett Publications, 1975.

Carter, Juanita E. and Young, Darroch F. Calculating Machines: A Ten-Key Approach. New York, New York: Houghton Mifflin Co., 1975.

Davidson, Jessica. Let's Start to Calculate. New Rochelle, New York: Cuisenaire Company of America, 1976.

Dolan, Daniel T. Let's Calculate. San Leandro, California: Lakeshore Curriculum Materials Co., 1976.

Etlinger, Len and Vitale, Marie. ETA Calculator Activity Book. Chicago, Illinois: Educational Teaching Aids, 1977.

Feldzamen, A. N. and Henle, Faye. The Calculator Handbook. New York: Berkley Publishing Co., 1973.

Fraser, Marshall. Elementary Algebra (Hand Held Calculator Edition). Palo Alto, California: Page-Ficklin Publishing Co., 1976.

Frenzel, Louis E., Jr. Ninety-Nine Ways to Know and Use Your Electronic Calculator. Indianapolis, Indiana: Howard W. Sams & Co., 1975.

Gilbert, Jack. Advanced Applications for Pocket Calculators. Blue Ridge Summit, Pennsylvania: Tab Books, 1975.

Hartman, Arlene. The Calculator Game Book for Kids of All Ages. New York: New American Library, Inc., 1977.

Henrici, Peter. Computation Analysis with the HP-25 Pocket Calculator. New York, New York: John Wiley & Sons, Inc., 1977.

Hunter, William L. Getting the Most Out of Your Electronic Calculator. Blue Ridge Summit, Pennsylvania: Tab Books, 1974.

Hyatt, Herman R.; Drooyan, Irving; and Carico, Charles C. Arithmetic With Push-Button Accuracy (Instructor's Manual). New York: John Wiley and Sons, Inc., 1977.

Immerzeel, George. Ideas and Activities for Using Calculators in the Classroom. Dansville, New York: The Instructor Publications, Inc., 1976.

Immerzeel, George. 77 Ideas for Using the Rockwell 18R in the Classroom. Anaheim, California: Rockwell International, 1976.

Immerzeel, George; and Ockenga, Earl. Calculator Activities--Book 1 and Book 2. Creative Publications and Omron Corporation of America.

Jacobs, Russell F. Problem Solving with the Calculator. Phoenix, Arizona: Jacobs Publishing Company, Inc., 1977.

Jamele, P. R. How to Select and Use a Calculator--or Getting the Most from Your 4-Function Calculator. Los Angeles: Crescent Publications, 1975.

Jefimenko, Oleg. How to Entertain with Your Pocket Calculator. Star City, West Virginia: Electret Scientific Co., 1975.

Judd, Wallace. Games, Tricks, and Puzzles for a Hand Calculator. Menlo Park, California: Dymax, 1974.

Judd, Wallace. Games Calculators Play. New York: Warner Books, 1975.

Kinsey, Vera G. Mastering Ten-Key Calculators: Electronic and Mechanical. New York, New York: Harcourt Brace Jovanovich, Inc.,1976.

Ladd, Norman E. Working With the Calculator in Beginning Algebra. Skokie, Illinois: National Textbook Co., 1976.

McCarty, George. Calculator Calculus. Palo Alto, California: Page-Ficklin Publications, 1975.

McCready, Richard R. Solving Business Problems with Calculators. 4th edition. Belmont, California: Wadsworth Publishing Co., Inc., 1972.

Meehan, J., et al. Solving Business Problems on the Electronic Calculator. New York: McGraw Hill Book Co., 1975.

Merchant, Ronald. Adding Machines and Calculators. New York, New York: John Wiley & Sons, 1974.

Miller, Don. Calculator Explorations. St. Cloud, Minnesota: Don Miller.

Miller, Lloyd E. Practice Problems for Business Education Using Electronic Calculators. Paramus, New Jersey: Sharp Electronics Corp., 1975.

Mims, Forrest M. Number Machines. New York, New York: David McKay Co., Inc., 1977.

Mullish, Henry. How to Get the Most Out of Your Pocket Calculator. New York: Collier Books, 1974.

Mullish, Henry. The Complete Pocket Calculator Handbook. New York: Collier Books, 1976.

Olney, Ross; and Olney, Pat. Pocket Calculator Fun and Games. New York, New York: Franklin Watts, Inc. (Subsidiary of Grolier Inc.), 1977.

Pallas, Norvin. Calculator Puzzles, Tricks & Games. New York: Sterling Publishing Co., Inc., 1976.

Papy, Frederique, et al. Math Play Therapy. CSMP Mathematics for the Intermediate Grades, Vol. 1. St. Louis, Missouri: CEMREL, Inc., 1977.

Pask, Gordon. Travels with a Calculator. Houston, Texas: Gulf Publishing Co., 1977.

Roberts, Edward M. Fingertip Math. Dallas: Texas Instruments, 1974.

Roberts, H. Edward. Electronic Calculators. Indianapolis, Indiana: Howard W. Sams & Co., Inc./Bobbs-Merrill, 1974.

Rogers, J.T. The Calculating Book: Fun and Games with Your Pocket Calculator. New York: Random House, 1975.

Rudolph, William B. and Claassen, A.D. The Calculator Book. Boston: Houghton Mifflin Co., 1976.

Salisbury, David F. Calculators, Power Tools for Thinking. Reprint from Christian Science Monitor. 1976.

Schlossberg, E. and Brockman, J. The Pocket Calculator Game Book. New York: William Morrow, 1975.

Seymour, Thomas J. Games Calculators Play! Rockford, Illinois: Seymour Publications, 1975.

Sharp, J. Norman C. The Calculator Workbox. Don Mills, Ontario: Addison-Wesley Publishers, 1977.

Skoll, Pearl. Coping with the Calculator. Northridge, California: Pearl Skoll, 1975.

Thiagarajan, Sivasailam, and Stolvitch, Harold D. Games with the Pocket Calculator. Menlo Park, California: Dymax, 1976.

Vannatta, Glen D. The Maximum from Your Minicalculator. Carmel, Indiana: Vancom Publications, 1976.

Vine, James. Boggle. Los Angeles, California: Price/Stern/Sloan Publishers, Inc., 1975.

Calculator Games for Kids. Racine, Wisconsin: Golden Press (Imprint of Western Publishing Co., Inc.), 1977.

Hewlett-Packard. Enter vs. =. Cupertino, California: Hewlett-Packard Co., 1974.

Hewlett-Packard. The Programming Book. Knoxville, Tennessee: Approach 13-3-Corporation, 1976.

Novus. Quiz Kid Quizbook. Sunnyvale, California: National Semiconductor Corp., 1974.

Novus. Whiz Kid Funbook. Sunnyvale, California: National Semiconductor Corp., 1974.

Sharp Electronics. Mathematics Using Electronic Calculators. Paramus, New Jersey: Sharp Electronics Corp., 1975.

Texas Instruments. The Great International Math on Keys Book. Dallas, Texas: Texas Instruments Learning Center, 1976.

The Texas Instruments Learning Center and The University of Denver Mathematics Laboratory. Basic Family Math. Dallas, Texas: Texas Instruments, Inc., 1976.

The Texas Instruments Learning Center and The University of Denver Mathematics Laboratory. Calculating Better Decisions. Dallas, Texas: Texas Instruments, Inc., 1977.

This publication was prepared pursuant to a contract with the National Institute of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official National Institute of Education position of policy.

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Introduction to
Research on Hand-Held Calculators, K-12

Bulletin No. 9
August 1977

For several years, research efforts have been directed at obtaining information on the effects of using hand-held calculators in elementary and secondary schools. This bulletin has been prepared to acquaint readers with these research efforts and to provide summary information regarding their major findings. In addition to an annotated bibliography listing the studies alphabetically, a table is provided for quick reference. For each study, the table lists the author(s) or major researcher(s), the date of the research report, the grade or age level(s) of the subjects involved in the study, the number (N) of subjects or classes involved, the length or duration of the study, the subject matter area, the type of research, and the major findings.

Most of the studies involved comparisons of Calculator and Non-calculator groups; that is, groups in which the calculator was used or was not used for instruction. Some of the studies had several sub-analyses of the data, so that 40 findings were noted. In 19 cases the Calculator group achieved significantly higher on paper-and-pencil tests (with which the calculator was not used). No significant differences were found in 18 instances. In only three instances was achievement significantly higher for the Non-calculator group.

Such gross tabulations provide some support for the belief that calculators can be used to promote achievement. At the same time, awareness needs to be maintained about the variety of focus, the limitations of research designs, the lack of sufficient descriptions to make a study replicable, and similar factors pertaining in some of the studies to date. Moreover, most of the research efforts were short-term, and dealt with fitting calculator applications into the existing curriculum. Attention must be directed to the long-term effects of the use of calculators, and to ways of using calculators to promote the learning of mathematics. Attitudes also need additional study.

RESEARCH ON HAND-HELD CALCULATORS, K-12

| Author | Date | Grade Level * | N | Length | Type of Research | Topic | Finding ** |
|---|---|---|---|---|---|---|---|
| Allen | 1976 | 6 | 6 c | 25 days | experimental | decimals, metric | posttest, NSD; retention, N > C |
| Anderson | 1977 | 7 | 12 c | 20 wks. | experimental | general | C improved attitudes; NSD, achievement (concepts, computation); C > N, problem solving |
| Borden | 1977 | 6 | 4 c | 4 wks. | experimental | decimals | Both groups achieved significant gains; N had significant negative change in attitude |
| Campbell/ Virgin | 1976a | 5-6 | 1 school | 7 mos. | experimental | checking | NSD, computation; C > N on concepts, problem solving in grade 5 |
| | 1976b | 4-6 | 183 t | | survey | attitudes of teachers | |
| Fischman | 1976 | 9-10 | 6 c | 1 sem. | experimental | business mathematics | NSD, attitude, concepts; C > N, skills |
| Hawthorne/ Sullivan | 1975 | 6 | 2 c | 1 year | action | general | C > N, computation, concepts; N > C, problem solving |
| Hutton | 1977 | 9 | | 4 wks. | experimental | powers, roots, radicals | NSD |
| Jamski | 1977 | 7 | 6 c | 4 wks. | experimental | rational numbers, percents, | Significant differences on posttest; NSD, retention |
| Jones | 1976 | 6 | 171 p | 9 wks. | experimental | general | C > N; NSD, attitudes |
| Lenhard | 1977 | 7-12 | 8 c | 1 sem. | experimental | general | NSD, achievement, attitudes |

* c = classes; p = pupils; t = teachers

** C = Calculator group; N = Non-calculator group; NSD = no significant differences

| Author | Date | Grade Level | N | Length | Type of Research | Topic | Finding |
|---|---|---|---|---|---|---|---|
| Luxton/ Spungin | 1976 | ages 15-20 | 15 p | 4 wks. | action | | Blind and partially sighted were able to use cassette manuals to learn to use three calculators. |
| Miller | 1977 | 5 | 4 grps. | 12 days | experi-mental | division | C > N, lower-ability groups, on skills, division; NSD between higher-ability groups |
| Muzeroll | 1976 | 7 | 207 p | 60 days | experi-mental | general | NSD, achievement, attitudes |
| Nelson; Bitter/ Nelson | 1976 1975 | 4-7 | 196 p | 1 summer | action | general | C > N |
| Quinn | 1976 | 8-9 | 184 p | 8 mos. | experi-mental | algebra | NSD, achievement; C had less anxiety, better self-concept |
| Rudnick/ Krulik | 1976 | 7 | 600 p | 1 year | experi-mental, survey | general | NSD, achievement, basic skills<br>Parental attitudes indicate reservations about calculator use |
| Scandura et al. | 1976 | k-2, 3-4 | | 1 summer | prelimi-nary | general | calculators found to be source of motivation |
| Schafer et al. | 1975 | 5 | 5 c | 2 days | prelimi-nary | general | C > N on calculator examples; NSD on non-calculator examples |
| Schnur/ Lang | 1976 | ages 9-14 | 60 p | 2 mos. | experi-mental | general | C > N |
| Shirey | 1976 | 10-12 | | 9 days | experi-mental | consumer, business math. | C > N, inquiry |
| Spencer | 1975 | 5-6 | 84 p | 8 wks. | experi-mental | general | C > N on grade 5 reasoning, grade 6 computation, total test |
| Sutherlin | 1977 | 5-6 | 8 c | 8 wks. | experi-mental | decimals, estimation | NSD, estimation |
| Vaughn | 1977 | 9 | 8 c | 8 wks. | experi-mental | decimals, percents | C > N, achievement; NSD, attitudes, retention |
| Wajeeh | 1976 | 9 | 13 c | 15 wks. | experi-mental | general math. | C > N, achievement; NSD, attitudes |

| Author | Date | Grade Level | N | Length | Type of Research | Topic | Finding |
|---|---|---|---|---|---|---|---|
| Weaver | 1976a | 2,3,5 | 7 c | | explora-tory | number sentences | |
| | 1976b | 3 | 2 c | | | addition, subtraction sentences | |
| Whitaker | 1977 | 1 | | 30 days | experi-mental | general | C > N, non-timed computation and verbal problem solving; N > C, concepts; NSD, timed computation, total achievement, attitude |
| Zepp | 1976 | 9, college | 179 p 198 col. | | experi-mental | proportions | NSD |
| MT | 1974 | teachers and others | | | survey | | |

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Research on Hand-Held Calculators, K-12

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Allen, Maxine Bogues. Effectiveness of Using Hand-Held Calculators for Learning Decimal Quantities and the Metric System. (Virginia Polytechnic Institute and State University, 1976.) Dissertation Abstracts International 37A: 850-851; August 1976.

During a 25-day unit on decimal algorithms and on the metric system, four intact sixth-grade classes used calculators for all computations while two classes used only paper and pencil. No significant differences between the two groups were found on the posttest, but on the retention test the group using paper and pencil only scored significantly higher on both the decimal and the metric tests than the calculator group.

Anderson, Lyle Eugene. The Effects of Using Restricted and Unrestricted Modes of Presentation With Electronic Calculators on the Achievement and Attitude of Seventh Grade Pupils. (University of Denver, 1976.) Dissertation Abstracts International 37A: 6321-6322; April 1977.

Three seventh-grade mathematics classes taught by the same teacher were randomly selected at each of four schools for the 20-week study. One class in each school was permitted restricted use of calculators (checking paper and pencil computations and as an aid in problem solving), a second class was permitted unrestricted calculator use, and the third class was not permitted to use calculators. Pupils using calculators showed improved attitudes toward mathematics but no change in achievement, understanding mathematical concepts, or computational skill. On an untimed problem solving test, pupils using calculators solved problems correctly at almost twice the rate of pupils not using calculators.

Borden, Virginia Lee. Teaching Decimal Concepts to Sixth Grade Students Using the Hand-Held Calculator. (University of Northern Colorado, 1976.) Dissertation Abstracts International 37A: 4192; January 1977.

A unit on decimals constructed to precede a study of common fractions was taught to four classes of sixth graders, with two of the classes using calculators while the other two classes did not. Both groups showed a significant gain in mathematics achievement of certain concepts and skills in decimals. It was not reported if any differences in achievement of attitude were found when the calculator group was compared to the non-calculator group. The non-calculator group showed a significant negative change in attitude toward mathematics.

Campbell, Patricia and Virgin, A.E. An Evaluation of Elementary School Mahtematics Programs Utilizing the Mini-Calculator. North York Board of Education, Ontario, Canada, July 1976. ERIC: ED 137 120. 42 pages.

For a seven-month period, fifth and sixth graders in one school had calculators available in their classrooms for checking their work, while at a second school no calculators were permitted. A standardized mathematics achievement test

and an attitudequestionnaire were given as pre- and posttests. On the computation subtest there were no significant differences in the gain scores between the two schools. On both the mathematics concepts and the problem-solving subtests, fifth graders in the calculator group scored significantly higher than fifth graders in the non-calculator group.

Campbell, Patricia and Virgin, Albert. A Survey of Elementary School Teachers' & Principals' Attitudes to Mathematics and Utilizing Mini-Calculators. North York Board of Education, Ontario, Canada, July 1976. ERIC: ED 137 121. 27 pages.

Investigator-constructed questionnaires were distributed to fourth-, fifth-, and sixth-grade teachers and to elementary school principals to determine their attitudes toward the use of calculators in the classroom. Results showed that just over half of the 183 teachers responding did not think that the use of a calculator would help them realize their teaching objectives for mathematics. Almost half of the teachers felt that the calculator could be introduced between grades 4 and 6, while 44% indicated a preference for after grade 6. Teachers and principals were not unlike in their attitudes toward the use of the calculator in the classroom and were consistent in identifying similar advantages and disadvantages of using calculators.

Fischman, Myrna Leah. New York City High School Students' Attitudes and Concept Learnings in Business Arithmetic When Using Electronic Calculators as Contrasted with Hand Calculation. (New York University, 1976.) Dissertation Abstracts International 37A: 774-775; August 1976.

Three business arithmetic classes of ninth and tenth graders used calculators while three other business arithmetic classes did not. All classes were taught the same material. No significant differences in attitudes toward business mathematics or in understanding of concepts were found between the calculator and the non-calculator group. However, the calculator group scored significantly higher on a test of arithmetic skills than did the non-calculator group.

Hawthorne, Frank S. and Sullivan, John J. Using Hand-Held Calculators in Sixth-Grade Mathematics Lessons. New York State Mathematics Teachers' Journal 25: 29-31; January 1975.

This is a report on the study by Barrett and Keefe, involving two sixth-grade classes. A posttest at the end of the year indicated that the students using calculators scored higher on tests of concepts and computation than a non-calculator group, but not as high on problem-solving tests.

Hutton, Lucreda Ann Williams. The Effects of the Use of Mini-Calculators on Attitude and Achievement in Mathematics. (Indiana University, 1976.) Dissertation Abstracts International 37A: 4934; February 1977.

A 4-week unit on powers, roots, and radicals was studied by one group of ninth-grade algebra students who had traditional instruction with no calculators, a second group who had traditional instruction but could use calculators during class, and a third group who had special calculator instruction plus access to calculators during class. No significant differences were found when groups were compared on achievement or attitude.

Jamski, William Donald. The Effect of Hand Calculator Use on the Achievement of Seventh Graders Learning Rational Number-Decimal-Percent Conversion Algorithms. (Indiana University, 1976.) Dissertation Abstracts International 37A: 4934-4935; February 1977.

Three classes of students at the seventh-grade level used calculators during a 4-week unit on finding equivalent forms for fractions, decimals, and percents, while three other classes did not use calculators. On an immediate posttest, a significant difference was identified between groups on items involving conversion from a simplified fraction to a decimal. No differences were found between groups when a retention test was given.

Jones, Edris Whitted. The Effect of the Hand-Held Calculator on Mathematics Achievement, Attitude and Self Concept of Sixth Grade Students. (Virginia Polytechnic Institute and State University, 1976.) Dissertation Abstracts International 37A: 1387; September 1976.

One hundred thirteen sixth-grade students used calculators for about an hour daily for 9 weeks, while another group of 58 sixth-graders used paper and pencil only. Results showed that students using calculators made significant gains in total achievement, computation, and concept scores; no differences were found in attitude or self-concept. Girls in the experimental group scored significantly higher on concepts than did boys.

Lenhard, Rodger William. Hand-Held Calculators in the Mathematics Classroom at Stuart Public School, Stuart, Nebraska. (Montana State University, 1976.) Dissertation Abstracts International 37A: 5661; March 1977.

Analysis of at least eight tests taken by a total of 125 secondary students in grades 7 through 12 showed no differences in performance between those using and not using calculators during the test on test scores, concept and computation errors, attitudes, time, and rank.

Luxton, Karen and Spungin, Susan Jay. Effectiveness of Calculator Instructional Materials: A Pilot Study. New Outlook for the Blind 70: 380-384; November 1976.

During this four-week study, 15 blind and partially sighted subjects ages 15 to 21 used and evaluated the instructional manuals for three calculators: the TSI Speech Plus, the Master Specialty Audio Response, and the AFB Braille Calculator. Data indicted that the students were able to use the cassette manuals to learn to use each calculator. Several suggested improvements for future development of materials are given.

Miller, Donald Peter. Effectiveness of Using Minicalculators as an Instructional Aid in Developing the Concept and Skill of Long Division at the Fifth Grade Level. (The Florida State University, 1976.) Dissertation Abstracts International 37A: 6327; April 1977.

Two fifth-grade classes were separated into a low group and a high group on the basis of a prerequitite skills test of multiplication, subtraction, and division by one-digit divisors. One class was chosen to use calculators during a 12-day unit on division while the other class was permitted the use of multiplication tables. The low groups were taught by an elementary education major. The low calculator group scored significantly higher than the low control group on posttests of prerequisite skills and division.

Muzeroll, Peter Arthur. Attitudes and Achievement in Mathematics in Student Choice and Non-Choice Learning Environments. (The University of Connecticut, 1975.) Dissertation Abstracts International 36A: 4233; January 1976.

One group of students was allowed to select activities from seven resource areas (one of which involved calculators), while the comparison group was taught under a no-choice option. A total of 207 seventh-graders participated. Results showed no significant differences in mathematics attitude or achievement between the two groups. Overall, there was a significant decline in students' attitudes toward mathematics from the end of grade 6 through the end of grade 7 for both groups of students.

Nelson, Dennis William. Effects of Using Hand Calculators on the Attitudes and Computational Skills of Children in Grades Four Through Seven. (Arizona State University, 1976.) Dissertation Abstracts International 37A: 3382-3383; December 1976.
See also: Bitter, Gary G. and Nelson, Dennis. Arizona Migrant Education Hand-Held Calculator Project. Migrant Educator 1: 1-3; 1975.

A total of 196 summer school students in grades 4 through 7 were placed in one of four different curricular programs: the regular mathematics program, the regular mathematics program plus calculators, a commercial calculator-involved curriculum, or a diagnosis-remediation calculator program. Findings showed that gains in basic computational skills and attitudes of students toward mathematics were significantly improved when students used hand calculators.

Quinn, Donald Ray. The Effect of the Usage of a Programmable Calculator upon Achievement and Attitude of Eighth and Ninth Grade Algebra Students. (Saint Louis University, 1975.) Dissertation Abstracts International 36A: 4234-4235; January 1975.

The programmable calculator was used in eighth- and ninth-grade algebra classes for evaluating algebraic expressions and for solving linear, quadratic, and systems of equations. Findings showed no significant differences in achievement when performance of students in the calculator classes was compared to performance of those in non-calculator algebra classes. However, students in the calculator classes showed less "anxiety toward mathematics" and had better "self-concept in mathematics" than students in non-calculator classes.

Rudnick, Jesse A. and Krulik, Stephen. The Minicalculator: Friend or Foe? Arithmetic Teacher 23: 654-656; December 1976.

The effect of the availability and use of a calculator on seventh-graders' mathematics achievement was investigated. Preliminary findings on parental attitude toward the use of calculators and on student achievement are discussed.

Scandura, Alice M.; Lowerre, George F.; Veneski, Jacqueline; and Scandura, Joseph M. Using Electronic Calculators with Elementary School Children. Educational Technology 16: 14-18; August 1976.

Four K-2 studies and one for grades 3-4 considered which mathematical topics could be taught most effectively with a hand-held calculator, which new mathematical topics could be successfully introduced when using such calculators, and what implications there might be for problem solving.

Schafer, Pauline; Bell, Max S.; and Crown, Warren D. Calculators in Some Fifth-Grade Classrooms: A Preliminary Look. Elementary School Journal 76: 27-31; October 1975.

Students in the calculator group scored significantly higher on calculator examples, while no differences were found on non-calculator examples between calculator and non-calculator groups.

Schnur, James O. and Lang, Jerry W. Just Pushing Buttons or Learning? -- A Case for Minicalculators. Arithmetic Teacher 23: 559-562; November 1976.

Groups using calculators gained significantly more whole number computational ability than control groups not using the calculator. Sex of student and calculator usage interaction was not significant, nor was the interaction between ethnic/economic background and gain in computational ability.

Shirey, John Reginald. The Effects of Computer-Augmented Instruction on Students' Achievement and Attitudes. (University of Oregon, 1976.) Dissertation Abstracts International 37A: 3386-3387; December 1976.

Tenth, eleventh, and twelfth graders in consumer and business mathematics classes were randomly assigned to receive computer-augmented instruction or a low-cost alternative using tables and calculators to complete inquiry exercises. The instructional unit covered nine days. Results showed that the calculator group did significantly more inquiry beyond the minimum required than did the computer group.

Spencer, JoAnn Nora. Using the Hand-Held Calculator in Intermediate Grade Arithmetic Instruction. (Lehigh University, 1974.) Dissertation Abstracts International 35A: 7048-7049; May 1975.

For an eight-week study, 40 fifth graders and 44 sixth graders were randomly assigned to either a calculator group or a non-calculator group. Both groups worked with computation sheets prepared by the experimenter. The calculator group scored significantly higher than the non-calculator group on the reasoning test in grade 5 and on the computation test and total arithmetic test in grade 6.

Sutherlin, William Norman. The Pocket Calculator: Its Effect on the Acquisition of Decimal Estimation Skills at Intermediate Grade Levels. (University of Oregon, 1976.) Dissertation Abstracts International 37A: 5663; March 1977.

As they studied a unit on decimal operations and on estimation techniques, four fifth- and sixth-grade classes used calculators while four other classes did not. No significant differences in estimation skills were found.

Vaughn, Larry Richard. A Problem of the Effects on Hand-Held Calculators and a Specially Designed Curriculum on Attitude toward Mathematics, Achievement in Mathematics, and Retention of Mathematical Skills. (University of Houston, 1976.) Dissertation Abstracts International 37A: 4938-4939; February 1977.

Four ninth-grade general mathematics classes used calculators as they studied decimals and percents for 8 weeks in a specially-designed curriculum, while four other classes received traditional instruction with no calculators.

Results showed that the calculator group scored significantly higher than the non-calculator group on an achievement test, but no differences between groups were found with respect to attitude or retention of mathematical skills.

Wajeeh, Abdullah. The Effect of a Program of Meaningful and Relevant Mathematics on the Achievement of the Ninth Grade General Mathematics Student. (Wayne State University, 1976.) Dissertation Abstracts International 37A: 2801-2802; November 1976.

The group of ninth-grade general mathematics students using an investigator-developed unit plus calculators for 15 weeks scored significantly higher on a standardized computation test than the group using only the developed unit, but there were no significant differences in attitudes.

Weaver, J. F. Calculator-influenced Explorations in School Mathematics: Number Sentences and Sentential Transformations I, II. Project Paper 76-1. Madison: Wisconsin Research and Development Center for Cognitive Learning, January 1976. ERIC: ED 123 088. 53 pages.

Explorations involving the use of calculators in connection with mathematics instruction were conducted with two fifth-grade classes, two second-grade classes, and three third-grade classes. The data suggested that pupils encountered no consequential problems with the mechanics of using simple four-function, algebraic-logic calculators in routine contexts, and that pupils elected not to use calculators in situations where their use is unnecessary or of no particular advantage. While elementary-school mathematics programs usually emphasize binary operations, project explorations have moved increasingly toward content interpretations in terms of unary operations.

Weaver, J. F. Calculator-influenced Explorations in School Mathematics: A Further Investigation of Third-grade Pupils' Performance on Open Addition and Subtraction Sentences. Project Paper 76-3. Madison: Research and Development Center for Cognitive Learning, University of Wisconsin, April 1976. ERIC: ED 123 089. 24 pages.

Limited systematic instruction was provided for two third-grade classes on a calculator-assisted approach to solving selected types of simple open addition and subtraction sentences involving three-place whole-number addends, moving from a guess-and-test procedure to more direct and efficient sentential transformations. Pupils exhibited a relatively high level of computational accuracy in their use of calculators (94%) but substantially lower levels of proficiency in providing mathematically correct solutions for "taught" and related "untaught" open-sentence types (ranging from 66% to 23%). Serious questions are raised regarding the appropriateness for young children of certain instructional approaches to the solution of simple open addition and subtraction sentences.

Whitaker, William Howard. A Study of Change in Achievement, Interest, and Attitudinal Variates Accompanying the Use of Electronic Calculators in a First Grade Mathematics Curriculum. (University of Southern California, 1977.) Dissertation Abstract International 38A: 97-98; July 1977.

The 30-day study examined the effect of calculator use with first graders upon achievement, attitudes, and interests related to mathematics. Each group completed daily worksheets, with one group checking their results on a calculator and the other group relying upon their teachers to check results. Findings indicated

that students using calculators were aided in non-timed computation and in solution to verbal problems but they displayed smaller gains in mathematics conceptualization. No differences were found for the variables of timed computations, total achievement gain, and attitude gain.

Zepp, Raymond Andrew. Reasoning Patterns and Computation on Proportions Problems, and Their Interaction with the Use of Pocket Calculators in Ninth Grade and College. (The Ohio State University, 1975.) Dissertation Abstracts International 36A: 5181; February 1976.

One hundred seventy ninth graders and 198 college freshmen were classified as having high, middle, or low ability in solving proportions. Half the students in each ability group were given calculators to use while working on a programmed unit in linear interpolation, while the rest of the students could only use paper and pencil for their computations. Results showed no significant differences between performances of students using calculators compared to those not using calculators, nor was there any significant interaction of use of calculators with ability to solve proportions. The hypothesis that students could understand a proportional train of thought better if the barrier of computation were removed was not borne out.

Where do You Stand? Computational Skill Is Passe. Mathematics Teacher 67: 485-488; October 1974.

A survey of teachers, mathematicians, and laymen is reported, with seven questions and percentage of responses noted.

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This publication was prepared pursuant to a contract with the National Institute of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official National Institute of Education position or policy.
August 1977: Revision of Reference Bulletin No. 2, April 1977.

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References on Desk Calculators, K-12

Bulletin No. 10
August 1977

Research

Advani, Kan. The Effect of the Use of Desk Calculators on Achievement and Attitude of Children with Learning and Behaviour Problems. A Research Report. December 1972. ERIC: ED 077 160. 10 pages.

Eighteen students (ages 12 to 15) used four calculators for six months to check mathematics problems. Comparisons of pre- and posttest data indicated significant increases in student interest and positive attitudes toward mathematics, while disruptive behaviours decreased.

Aldridge, Wanda Scott. Effects of Electronic Calculators on Achievement of Middle School Remedial Mathematics Students. (University of Georgia, 1976.) Dissertation Abstracts International 37A: 4078; January 1977.

Eighty-three middle school remedial mathematics students used calculators as they worked through lessons in the Computational Skills Development Kit on an individualized basis for 4 weeks, while 90 students did all the required calculation with paper and pencil. Results on a standardized arithmetic skills posttest showed that the non-calculator group scored significantly higher ($p < .001$) than the calculator group. No significant differences between groups were found when compared by grade level.

Beck, Lois L. A Report on the Use of Calculators. Arithmetic Teacher 7: 103; February 1960.

Fourth-, fifth-, and sixth-grade classes used Monroe Educator calculators: these calculators perform the basic operations in much the same way they are done with paper and pencil. Although complete results were unavailable at the time of writing, several observations were made. The calculators could be operated by the students; when used as a regular classroom tool, they tended to motivate and reinforce understanding and achievement in basic skills. Children seemed to enjoy using the calculators, and to exhibit better work habits. Place-value concepts were reinforced.

Betts, Emmett A. A Preliminary Investigation of the Value of a Calculating Machine for Arithmetic Instruction. Education 58: 229-235; December 1937.

The effect of practice with a calculating machine on the pupil's problem-solving techniques and computational skills was studied. Thirteen pupils in the second half of sixth grade completed the year's work in the six-week treatment period. Gain scores from four tests were compared, with improvement found in each case. Pupils were able to analyze more problems in the time available than they usually did.

Broussard, Vernon; Fields, Albert; and Reusswig, James. A Comprehensive Mathematics Program. AV Instruction 14: 43-44, 46; February 1969.

A program for low achievers in grades 7-9 from disadvantaged areas which emphasized real-world applications and use of flow charts, calculators, and other materials, resulted in significant achievement gain. Sixty per cent of the students who had participated in the program continued to take mathematics courses, compared with 40 per cent in a control group.

Buchman, Aaron L. The Use of Calculators and Computers in Mathematics Instruction in New York State High Schools. School Science and Mathematics 69: 385-392; May 1969.

Only 13 per cent of the schools reported (in 1967-68) having calculators in the mathematics department, with 2 percent of these having computer features. Five per cent of the schools had computer facilities which were used by mathematics classes.

Cech, Joseph Philip. The Effect the Use of Desk Calculators Has on Attitude and Achievement in Ninth-Grade General Mathematics Classes. (Indiana University, 1970.) Dissertation Abstracts International 31A: 2784; December 1970.
See also: Cech, Joseph P. The Effect of the Use of Desk Calculators on Attitude and Achievement with Low-Achieving Ninth Graders. Mathematics Teacher 65; 183-186; February 1972.

The two main reasons for using calculators with low achievers in mathematics classes are motivation and achievement. This study of calculator effectiveness involved two teachers each teaching a calculator section and a regular section of general mathematics for seven weeks. Students in the experimental group were encouraged, but not forced, to check answers with the calculators. All classes were given pre- and posttests of attitude and achievement. Results did not support the hypothesis that students using calculators would show positive gains in attitude toward mathematics or increased paper-and-pencil computational skill. Students could compute better with the calculator than without it, however.

Durrance, Victor Rodney. The Effect of the Rotary Calculator on Arithmetic Achievement in Grades Six, Seven, and Eight. (George Peabody College for Teachers, 1964.) Dissertation Abstracts 25: 6307; May 1965.

From grades 6-8 in a single school, 35 pairs of students were matched according to IQ and grade placement in arithmetic. One from each pair was then selected to use the calculator. Analysis of data from the nine-week study indicated that in computation, reasoning, and concepts, the calculator had no effect except in the area of reasoning in grade 7.

Ellis, June and Corum, Al. Functions of the Calculator in the Mathematics Laboratory for Low Achievers. 1969. ERIC: ED 040 847. 46 pages.

An experimental and a control class were administered pre- and posttests to check the effects of calculator use on the achievement, attitude, and academic motivation of low achievers. The use of printing calculators did not produce a statistically significant change in mathematics achievement. More favorable attitudes and weaker academic motivation were recorded for both groups at the end of the experiment.

Fehr, Howard F.; McMeen, George; and Sobel, Max. Using Hand-Operated Computing Machines in Learning Arithmetic. Arithmetic Teacher 3: 145-150; October 1956.

A controlled experiment on learning multiplication by using a two-digit multiplier was conducted for a two-week period. No significant difference was found in the performance of students in experimental and control groups. However, the experimenters felt that longer use of the devices might have produced an effect, and therefore conducted a half-year experiment using the Monroe Educator model hand-operated calculator. Students using this machine made significant gains in both computation and reasoning. Although their gains were greater than those of a control group, these differences were not statistically significant. Both students and teachers using calculators had a very positive attitude toward calculator use in the mathematics classroom.

Findley, Robert Earl. An Evaluation of the Effectiveness of a Textbook, Advanced General Math, Used by Ninth Grade General Mathematics Classes. (Colorado State College, 1966.) Dissertation Abstracts 27A: 2440-2441; February 1967.

The group using the traditional textbook and calculators for a full year gained significantly more than the group using the traditional textbook alone or the modern textbook with calculators, but only on arithmetic fundamentals achievement.

Gaslin, William Lee. A Comparison of Achievement and Attitudes of Students Using Conventional or Calculator-Based Algorithms for Operations on Positive Rational Numbers in Ninth-Grade General Mathematics. Dissertation Abstracts International 33A: 2217; November 1972.
See also: Gaslin, William L. A Comparison of Achievement and Attitudes of Students Using Conventional or Calculator-Based Algorithms for Operations on Positive Rational Numbers in Ninth-Grade General Mathematics. Journal for Research in Mathematics Education 6: 95-108; March 1975.

Use of units in which fractional numbers were converted to decimals and examples then solved on a calculator was found to be a "viable alternative" to use of conventional textbooks (including fractions) with or without a calculator, for low-ability or low-achieving students.

Hohlfeld, Joseph Francis. Effectiveness of an Immediate Feedback Device for Learning Basic Multiplication Facts. (Indiana University, 1973.) Dissertation Abstracts International 34A: 4563; February 1974.

The effectiveness of an electronic calculator, programmed as an immediate feedback device, was compared with the effectiveness of pencil-and-paper exercises without immediate feedback for the learning of the 100 basic multiplication combinations. Twelve students in each of seven fifth-grade classes were identified as low achievers and randomly assigned to treatment. Significant differences favored the electronic calculator practice group over the pencil-and-paper practice group on both acquisition and short-term retention, but not on long-term retention (one month or three-and-one-half months retention periods).

Johnson, Randall Erland. The Effect of Activity Oriented Lessons on the Achievement and Attitudes of Seventh Grade Students in Mathematics. (University of Minnesota, 1970.) Dissertation Abstracts International 32A: 305; July 1971.

Activity-oriented instruction, including one treatment in which calculators were used, did not appear to be more effective than instruction with little or no emphasis on activities, for units in number theory, geometry and measurement, and rational numbers.

Keough, John J. and Burke, Gerald W. Utilizing an Electronic Calculator to Facilitate Instruction in Mathematics in the 11th and 12th Grades. Final Report. July 1969. ERIC: ED 037 345. 60 pages.

The group using calculators achieved significantly more on a standardized test than did a group not using them.

Ladd, Norman Elmer. The Effects of Electronic Calculators on Attitude and Achievement of Ninth Grade Low Achievers in Mathematics. (Southern Illinois University, 1973.) Dissertation Abstracts International 34A: 5589; March 1974.

Two hundred one low achievers were randomly scheduled into one of five control sections or one of five experimental sections. All groups followed the same lesson sequence, with control groups using only paper and pencil for all calculations and experimental sections using electronic calculators. Significant differences were found on both attitude and achievement tests from pre- to post-treatment for both groups, but no significant differences in posttest mean scores were found between groups.

Longstaff, F.R. et al. Desk Calculators in the Mathematics Classroom. June 1968. ERIC: ED 029 498. 11 pages

This study was designed to test the use of calculators with two groups of ninth graders and one group of fifth graders. The findings were equivocal, concerning the effect of calculators on students' performance, self-confidence, and attitudes toward mathematics. Teacher enthusiasm for calculator use was unrelated to student performance. Teacher enthusiasm was highest in classes of low-average IQ. While some teachers felt calculators interfered with their daily operations, others felt that the productivity of students increased, especially among those previously incapable of producing. Classroom behavior problems were eased.

Mastbaum, Sol. A Study of the Relative Effectiveness of Electric Calculators or Computational Skills Kits in the Teaching of Mathematics. (University of Minnesota, 1969.) Dissertation Abstracts International 30A: 2422-2423; December 1969.

The calculator, when used as a teaching aid with slow learners in mathematics in the seventh and eighth grades, did not significantly improve attitude, increase mathematical achievement, or increase non-calculator computational skill, mastery of mathematical concepts, or ability to solve mathematical problems. However, the students did at least as well in all areas as those students not using calculators.

Schott, A.F. Adventure in Arithmetic. Educational Screen 34: 65-67; 1955.

A study with students in grades 4 through 9 is reported; the groups using calculators achieved higher than groups not using calculators.

Shea, James Francis. The Effects on Achievement and Attitude Among Fourth Grade Students Using Calculator Flow-Charting Instruction vs. Conventional Instruction in Arithmetic. (New York University, 1973.) Dissertation Abstracts International 34A: 7499; June 1974.

The group having calculator instruction had significantly higher scores than a group not using calculators on computation but not other tests or an attitude measure.

Stocks, Sister Tina Marie. The Development of an Instructional System Which Incorporates the Use of an Electric Desk Calculator as an Aid to Teaching the Concept of Long Division to Educable Mentally Retarded Adolescents. (Columbia University, 1972,) Dissertation Abstracts International 33A: 1049-1050; September 1972.

All students demonstrated an improvement in scores between pre- and posttest; however, no tests of significance were made. A positive change in attitude was also found.

Other References

Albrecht, Robert L. and others. The Role of Electronic Computers and Calculators in Mathematics Instruction. In Instructional Aids in Mathematics (edited by Emil J. Berger). Thirty-fourth Yearbook of the National Council of Teachers of Mathematics. Washington: The Council, 1973. Pp. 181-187.

Various types of computing devices are described, and their usefulness in the classroom discussed. Scant attention is devoted to calculators in general, and none to the hand-held calculator as a distinct instructional aid. The authors state that electronic calculators are "far more powerful problem solving tools than conventional machines."

Asmus, Paul. Calculators vs. Minis. Datamation 18: 55-58; April 1972.

A summary of key features to compare when deciding on either a programmable calculator or a minicomputer are listed. Consideration is given to the kinds of work to be done, flexibility needed, experience of users, operating features, and price.

Clark, Hyla and Barandes, Larry. Desktop Calculators That Print Their Results. Popular Mechanics 147: 187-189; April 1977.

Advantages of printing calculators are discussed. Consumer concerns (such as power source, types of display, noise factors, special keys, memory) are identified. Four printing calculator models are described in detail.

Lesjack, J.J. Computation: Beat the Machine. Grade Teacher 87: 150-153; March 1970.

A game in which teams of students compete with each other using an adding machine can be used to practice and enhance basic skills.

Millikin, G. and Siegel, D. Kit for Teaching Calculating and Computing Devices. Teaching Exceptional Children 3: 17-22; Fall 1970.

A kit was designed to introduce gifted students to basic computer activities. The kit included an abacus, slide rule, desk calculator, punch-card equipment, and an electronic computer, as well as books. A series of objectives and activities is outlined.

Smith, J.R. Desk Calculators. Brooklyn Heights, New York: Beekman Publishers, Inc., 1973.

Van Atta, Frank. Calculators in the Classroom. Arithmetic Teacher 14: 650-651; December 1967.

Many problems cannot be done by the pupil alone, but can be handled by the pupil-plus-computer combination. Two such problems involve exponents and the Pythagorean theorem. The facility to do many computations enables students to get a better feel for rational and irrational numbers and for the definition of a logarithm.

Basic Mathematics Machine Calculator Course. Windsor Public Schools, Conn., 1969. ERIC: ED 069 469. 518 pages.

This series of four text-workbooks was designed for tenth-grade mathematics students who have exhibited lack of problem-solving skills. Electric desk calculators are to be used with the text. In the first five chapters of the series, students learn how to use the machine while reviewing basic operations with whole numbers, decimals, fractions, and percents. The rest of the chapters present word problems in simple consumer mathematics, business activities, installment buying, banking, stocks and bonds, insurance, taxes, and utilities. A chapter on the use of formulas is included.

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August 1977: Revision of Reference Bulletin No. 3, April 1977.

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Introduction to
Pros and Cons of Using Hand-Held Calculators

Bulletin No. 11
August 1977

Should the use of calculators be permitted in elementary and secondary schools? Many of us concerned with education are facing this question and its possible implications for curricula in the elementary and secondary school. This bulletin has been prepared to provide summary information regarding the pros and cons of using hand-held calculators in schools. In the first section, frequently cited reasons for using calculators in schools are listed. This list is followed by another which gives frequently cited reasons for not using calculators in schools. Each of these lists was taken from Electronic Hand Calculators: The Implications for Pre-College Education, a report prepared for National Science Foundation by Suydam (1976). A check of more recently published literature indicated that these reasons, derived from a survey sent in the spring of 1975, are still the ones most frequently cited. The third and final section of this bulletin provides an alphabetized list of references which contain information relevant to the pros-and-cons issue of the calculator controversy. It is hoped that this bulletin will assist you in forming your own position on this important issue.

## Reasons for Using Calculators

(1) They aid in computation. They are practical, convenient, and efficient. They remove drudgery and save time on tedious calculation. They are less frustrating, especially for low achievers. They encourage speed and accuracy.

(2) They facilitate understanding and concept development.

(3) They lessen the need for memorization, especially as they reinforce basic facts and concepts with immediate feedback.

(4) They help in problem solving. Problems can be more realistic and the scope of problem solving can be enlarged.

(5) They motivate. They encourage curiosity, positive attitudes, and independence.

(6) They aid in exploring, understanding, and learning algorithmic processes.

(7) They encourage discovery, exploration, and creativity.

(8) They exist. They are here to stay in the "real world", so we cannot ignore them.

The last reason -- the pragmatic fact that they exist and that they are appearing in the hands of increasing numbers of students -- is perhaps the most compelling. How they can be used to facilitate each of the other seven beliefs is therefore a question that must be attacked.

## Reasons for Not Using Calculators

(1) They could be used as substitutes for developing computational skills: students may not be motivated to master basic facts and algorithms.

(2) They are not available to all students. Because they cannot afford a calculator, some students are at a disadvantage.

(3) They may give a false impression of what mathematics is. Mathematics may be equated to computation, performed without thinking. Emphasis is on the product rather than on the process; structure is deemphasized. Mental laziness and too much dependence are encouraged; lack of understanding is promoted. Some students and teachers will misuse them.

(4) They are faddish. There is little planning or research.

(5) They lead to maintenance and security problems.

[Note: The security problem appears to be almost non-existent, according to reports from those actually working with calculators.]

The first concern--that students will not learn basic mathematical skills--is one expressed most frequently by parents and by other members of the lay public, as reflected (and created) by newspaper articles. But it builds a strawman, for few educators believe that children should use calculators in place of learning basic mathematical skills. Rather, there is a strong belief that calculators can help children to develop and learn more mathematical skills and ideas than is possible without the use of calculators. Much serious attention must be given by teachers and others to proving that this belief can be implemented and become fact.

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Pros and Cons of Using Hand-Held Calculators

Bulletin No. 11
August 1977

Bell, Max S. Calculators in Elementary Schools? Some Tentative Guidelines and Questions Based on Classroom Experience. Arithmetic Teacher 23: 502-509; November 1976.

Bell, Max; Esty, Edward; Payne, Joseph N.; and Suydam, Marilyn N. Hand-held Calculators: Past, Present, and Future. In Organizing for Mathematics Instruction, 1977 NCTM Yearbook. Reston, Virginia: National Council of Teachers of Mathematics, 1977.

Denman, Theresa. Calculators in Class. Instructor 83: 56-57; February 1974.

Etlinger, Leonard. The Electronic Calculator: A New Trend in School Mathematics. Educational Technology 14: 43-45; December 1974.

Grosswirth, Marvin. Calculators in the Classroom. Datamation 95: 90-91, 95; March 1975.

Gwynne, Peter. New York View: Calculator Boom. New Scientist 65: 231-232; January 23, 1975.

Harrington, Ty. Those Hand-held Calculators Could be a Blinking Useful Tool for Schools. American School Board Journal 163: 44, 46; April 1976.

Hawthorne, Frank S. Hand-held Calculator: Help or Hindrance? Arithmetic Teacher 20: 671-672; December 1973.

Higgins, Jon L. Mathematics Programs Are Changing. Education Digest 40: 56-58; December 1974. (Reprint from NASSP Curriculum Report 4: October 1975.)

Immerzeel, George. The Hand-held Calculator. Arithmetic Teacher 23: 230-231; April 1976.

Judd, Wallace, Rx for Classroom Math Blahs: A New Case for the Calculator. Learning 3: 41-48; March 1975.

Kibler, Tom R. and Campbell, Patricia B. Reading, Writing and Computing: Skills of the Future. Educational Technology 16: 44-46; September 1976.

Lewis, Philip. Minicalculators have Maxi-impact. Nation's Schools 93: 60, 62; May 1974.

Machlowitz, Eleanore. Electronic Calculators--Friend of Foe of Instruction? Mathematics Teacher 69: 104-106; February 1976. (See also Education Digest 41: 46-48; April 1976.)

Pendleton, Deedee. Calculators in the Classroom. Science News 107: 175, 181; March 15, 1975. (See also: Creative Computing, January-February 1976.)

Quinn, Donald R. Yes or No? Calculators in the Classroom. NASSP Bulletin 60: 77-80; January 1976.

Rogers, Joy J. The Electronic Calculator--Another Teaching Aid? Arithmetic Teacher 23: 527-530; November 1976.

Shumway, Richard J. Hand Calculators; Where Do You Stand? Arithmetic Teacher 23: 569-572; November 1976.

Suydam, Marilyn N. Electronic Hand Calculators: The Implications for Pre-College Education. Final Report, National Science Foundation, February 1976. ERIC: ED 127 205 377 pages; ED 124 205 159 pages.

Swartz, Clifford. Editorial: Ban the Calculator. Physics Teacher 14: 134; March 1976.

Euclid Conference on Basic Mathematical Skills and Learning. National Institute of Education, 1975. Volume I: Contributed Position Papers. ERIC: ED 125 908. Volume II: Working Group Reports. ERIC: ED 125 909. 49 pages.

Overview and Analysis of School Mathematics Grades K-12. Washington: Conference Board of the Mathematical Sciences, National Advisory Committee on Mathematical Education (NACOME), November 1975. ERIC: ED 115 512. 157 pages.

Report of the Conference on Needed Research and Development on Hand-Held Calculators in School Mathematics. National Institute of Education and National Science Foundation, 1977. (Available from Ed Esty, Mail Stop 7, NIE, 1200 19th Street NW, Washington, D.C. 20208.) ERIC: SE 022 565. 60 pages.

This publication was prepared pursuant to a contract with the National Institute of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official National Institute of Education position or policy.
August 1977: Revision of Reference Bulletin No. 4, April 1977.

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Selecting a Calculator

Bulletin No. 12
August 1977

Ballotto, S. Calculators--Powerful and Portable. Administrative Management 33: 66-80; February 1972.
See also: Calculators--They Just Keep Multiplying. Administrative Management 33: 68; August 1972.

Descriptions of calculator models introduced up to early 1972 are provided.

Berger, I. Electronic Calculators: How to Choose the Right One. Popular Mechanics 139: 86-90; February 1973.

Features to look for, how much to spend, and consideration of one's particular needs are discussed. Both desk and hand-held calculators are considered.

Berger, I. Calculators Get Smaller, Smarter, and Cheaper. Popular Mechanics 142: 70-75; December 1974.

Features to look for and what models have those features are indicated in this guide to buying a hand-held calculator.

Budlong, Thomas S. What to Look for in a Microcalculator. Machine Design 44: 155-161; November 14, 1972.

A checklist of features to consider when choosing a hand-held scientific calculator are listed. Features are described, with a summary of the characteristics of 17 engineering calculators.

Caravella, Joseph R. A Consumer's Guide to Minicalculators. Washington: National Education Association, 1976.
See also: Selecting a Minicalculator. Arithmetic Teacher 23: 547-550; November 1976; Mathematics Teacher 70: 360-363; April 1977.

Checklists are provided which are designed to help educators select an appropriate calculator for particular situations.

Caravella, Joseph R. Minicalculators in the Classroom. Washington: National Education Association, 1977.

The positive contributions of the calculator to basic education are explored. The introduction discusses questions educators ask about the use of the calculator. The first section briefly describes uses of the calculator in the classroom (as a time saver, for reinforcement, for motivation, as an aid to conceptualizing, and for applications), discusses research on calculators, describes NCTM involvement, and presents the NACOME recommendations concerning

calculators. The second section covers the implications of the use of the calculator in terms of curriculum, teacher in-service education, classroom management, instruction, and testing and evaluation. The third section gives guidelines for selecting and using calculators. The final section includes classroom activities keyed to the various functions of the calculator.

Clark, Hyla and Barandes, Larry. Desktop Calculators that Print Their Results. Popular Mechanics 147: 187-189; April 1977.

Advantages of printing calculators are discussed. Consumer concerns (such as power source, types of display, noise factors, special keys, memory) are identified. Four printing calculator models are described in detail.

Deeson, Eric. The Electronic Calculator. Physics Education 9: 419-421; September 1974.

Features of calculators such as precision and constant keys are briefly discussed.

Dohleman, L. What to Look For in an Electronic Calculator. Business Education Forum 27: 32-33; March 1973.

Features to consider when buying calculators for business or business education purposes include output type, decimal control, automatic rounding, portability, and programmability. It is suggested that buyers know terminology pertaining to the machine and test machines with the types of problems to be used in class.

Free, J. R. P.S. Buyers Guide to Under $100 Electronic Calculators. Popular Science 202: 86-88, 156; March 1973.
See also: Now There's a Personal Calculator for Every Purse and Purpose. Popular Science 206: 78-81, 136; February 1975.

Features and functions for various models are tabulated.

Free, John. Those Work-Saving, Problem Solving Programmable Calculators. Popular Science 210: 64, 66, 70; February 1977.

Three groups of programmable calculators are identified: key programmable (volatile memory), card programmable, and key programmable (non-volatile memory). (Volatile memories are erased and lose the program when the power is shut off.) Eleven calculators are compared on the following features: program steps, branching, addressable memories, logic, stack registers (reverse Polish notation), parenthesis levels, pending operations (algebraic operating system), and price. Two programs are given.

Frye, J.T. Buying and Using a Pocket Calculator. Popular Electronics 5: 62-64; May 1974.

Some common-sense things to look for when buying an electronic calculator are given. Some algorithms are also presented, for use with the less expensive calculators which do not have all capabilities built in.

Frye, John T. Selecting a Calculator. Popular Electronics 8: 94-96; December 1975.

Who will use the calculator and for what purpose, how much mathematics the user has and/or will study, and how much the buyer wants to pay should be considered when purchasing a calculator.

Hardcast, S. How to Select an Electronic Calculator. Electrical Review 194: 753; 1974.

Features to consider when selecting a calculator are noted.

Jamele, P.R. How to Select and Use a Calculator--or Getting the Most from Your 4-Function Calculator. Los Angeles: Crescent Publication, 1975.

Special features of different calculators are explained. Instructions for solving some special problems with a four-function calculator are given; algebraic equations, exponents, higher roots, geometric problems, annuities, linear interpolation, series evaluation, and use of the calculator when answers exceed the eight-digit capacity are covered.

Karp, Stewart. Calculators for the Chemist. Journal of Chemical Education 52A: 346-350; July 1975.

This is the first part of a two-part article surveying calculators of interest to the chemist. The range of electronic calculators currently available and their capabilities are surveyed.

Karp, Stewart. Calculators for the Chemist. Journal of Chemical Education 52A: 373-379; August 1975.

This is the second part of a two-part article surveying calculators of interest to the chemist. Desk top calculators now on the market are described, including manufacturers, prices, and functions performed. A table of specifications for programmable desk calculators is provided.

LaBar, Martin; Wilcox, Floyd; and Rickman, Claude M. Programmable Calculators as Teaching Aids and Alternatives to Computers. School Science and Mathematics 74: 647-650; December 1974.

The authors provide a list of calculators which have a capacity for handling programs, and a list of programs for such calculators which are available at cost. They argue that the use of these materials at many levels of mathematics instruction enhances both motivation and understanding.

Mims, Forrest M. Here are the New Programmable Calculators! Popular Electronics 9: 29-35; May 1976.

Reverse Polish notation and algebraic methods of entry, and branching and conditional-comparison capabilities of programmable calculators are discussed. A shopper's guide to four elementary programmable models is provided. Sample programs for determining volume of a cylinder, for incrementing a number, for squaring consecutive integers with a display of each result, and for a Hi-Lo game area included.

Stein, Philip. Small World. Computer Decisions 8: 14; May 1976.

Computer-like functions which can now be done by electronic desk calculators are described, and areas where calculators are deficient are listed.

Weaver, Peter. Tips for Buying a Pocket Calculator. Creative Computing 2: 17; January-February 1976.

Keyboard, number display, batteries, logic systems, and warranties are briefly discussed.

Consumer Bulletin 55: 14-18; September 1972.
56: 15-19; May 1973.

Features, prices, and ratings are included in these reports.

Consumer Reports 38: 372-377; June 1973.
38: 663; November 1973.
40: 533-541; September 1975.
41: 86-87; February 1976.
42: 5-6; January 1977.

Basic characteristics, prices, and ratings for calculators are listed.

Consumer's Research Magazine 57: 7-12; September 1974.
58: 19; January 1975.
58: 13-16; April 1975.
58: 65-66; October 1975.
59: 150-152; October 1976.
59: 7-12; December 1976.

Characteristics and ratings of calculators are given.

Calculators. Consumer Guide 1975 Consumer Buying Guide. New York: New American Library, Signet edition, 1975. Pp. 340-343.

Ratings for various types of calculators are presented.

Electronic Calculators. Changing Times 27: 39-41; July 27, 1973.

Different characteristics of calculators are considered, with a summary for twelve hand-held and eleven desk calculators.

Electronic Calculators. The Complete Buyer's Guide: Best Values '75. New York: Service Communications, Guide No. 18, 1975. Pp. 49-64.

Various calculators are evaluated.

Electronic Calculators 1976. Hackensack, New Jersey: Buyers Laboratory Inc., 1976.

Features of various calculators are listed.

How to Pick an Electronic Calculator. Better Homes and Gardens 51: 162; April 1973.

Some features to look for when buying a hand-held calculator include floating decimal, negative function, clear key, and power source.

Mathematics Teacher. New Products, Programs, Publications.

In this monthly feature of the NCTM journal, calculators and materials for use with calculators in the classroom are frequently reviewed.

What to Look for Before You Buy an Advanced Calculator. Corvallis, Oregon: Hewlett-Packard (Dept. 225A, 1000 N.E. Circle Blvd., 97330), 1976.

General types of advanced calculators, calculator logic, special features and functions, programmable calculators, and calculator construction are topics discussed in this booklet.

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August 1977: Revision of Reference Bulletin No. 6, April 1977.

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References on Calculators, Post-Secondary Level

Bulletin No. 13
August 1977

*Ayers, Sharon Whitton. The Effects of Situational Problem-Solving and Electronic Calculating Instruments in a College Level Introductory Statistics Course. (Georgia State University - School of Education, 1976.) Dissertation Abstracts International 37A: 6322-6323; April 1977.

For an eight-week period, each of four intact introductory statistics classes (n = 172) was randomly assigned to one of four treatment conditions corresponding to two instructional modes (emphases on situational problem solving vs. no such emphasis) and two computational methods (access to electronic calculating instruments vs. no such access). Significant main effects of computational achievement on statistics content achievement and of instructional mode on both attitude toward mathematics and view of statistics were found.

*Bukowski, Joseph E. A Survey of Attitudes on the Use of Calculators in the College Classroom. (Ed. D. Practicum, Nova University). June 1975. ERIC: ED 129 613. 20 pages.

This study focused on faculty and student attitudes toward the use of calculators in college accounting and business mathematics courses. Two different surveys were used; one was administered to 35 full-time and part-time faculty in the accounting and business mathematics areas at one college, while a second survey was administered to a random sample of 244 students. Responses from both the faculty and students indicated fairly consistent attitudes. A seemingly larger portion of students felt that calculators should be allowed unconditionally, while the faculty appeared to have some reservations on the use of calculators, especially in classes of business mathematics.

*Burger, Vernon K. Design, Production, Evaluation, and Revision of a Self-Instructional Package for the HP-45 Electronic Slide Rule. (Ed. D. Practicum, Nova University). August 1974. ERIC: ED 104 721.

The author designed an instructional package including slides and tape cassettes for individual use by students learning to use a hand calculator to perform computations. Students (n = 17) using the package were given pretests and posttests of ability and attitude. On the three sets of cognitive objectives, mastery was achieved by 96 percent, 76 percent, and 76 percent of the students, respectively. All students reported favorable attitudes to the unit. The author discusses planned revisions of the program, and relationships among the variables.

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*Research

Clark, C.J.; Kuemmerle, E.W.; and Lieto, L.R. Programmable Calculators: Uses in Freshman Chemistry Laboratories. Journal of Chemical Education 52: 423; July 1975.

Two uses for the programmable calculator in the laboratory are suggested: as a means of determining whether a student's raw data from a laboratory experiment fall within acceptable tolerance limits, and as a means of checking the reliability of unknowns and grading on quantitative experiments.

Craver, W. Lionel, Jr. Pocket Calculators and Classroom Testing. Educational Research and Methods 8: 72; Spring 1976.

The problems that arise in test situations when some, but not all, students use calculators are discussed, and some solutions to these problems are suggested.

DeJong, Kees A. Electronic Calculators Facilitate Solution of Problems in Structural Geology. Journal of Geological Education 23: 125-128; September 1975.

Three general types of applied problems in structural geology are discussed and trigonometric solutions are indicated. In addition, a five-example problem set is included.

Dodge, C.W. Problem and Solution. American Mathematical Monthly 83: 136-137; February 1976.

A solution is given to the problem, "Given a calculator with no memory, but with a squaring key, find the smallest power of n that cannot be computed without entering the value of n at least k times in the keyboard."

Hayman, H.J.G. Stereoscopic Diagrams Prepared by a Desk Calculator and Plotter. Journal of Chemical Education 54: 31-34; January 1977.

The use of a Hewlett-Packard 9810A programmable desk calculator with plotter for drawing ball-and-line stereopairs as well as three-dimensional structural formulas which are useful for teaching stereochemical principles and molecular structure is described.

Huffman, Harry and Welter, Clyde W. Updating Business Education Programs. Business Education Forum 30: 5-13; January 1976.

Among new technological developments affecting business education courses is the calculator. A course in business applications of the calculator at one university is noted.

Kitchen, William. Utilization of Electronic Calculators in Engineering, Science, and Mathematics Programs. MATYC Journal 5: 9; Fall 1971.

Using calculators in college courses is discussed.

*Kruse, Harry Rudolph and Burkett, Hugh Alan. Investigation of Card Programmable and Chip Programmable Pocket Calculators and Calculators Systems for Use at Naval Postgraduate School and in the Naval Establishment. Master's Thesis, Naval Postgraduate School, Monterey, California, March 1977.

The usefulness of card-programmable hand-held calculators in the management curricula of the Naval Postgraduate School and in the fleet were investigated, using manufacturer-provided information, NPS classroom experimentation, "hands-on" programming, interviews, and other literature. All aspects of calculator functions, programming, and programmability were surveyed with particular emphases on educational and practical applications. It was concluded that calculators provide significant advantages in teaching or learning mathematical concepts and that they are potentially important management and tactical support tools navy-wide. In addition, "thinking process transmutation", discovered in this study, is concluded to be an inevitable and important by-product of calculator programming which significantly improves the user's overall analytic capacity.

Leitzel, Joan and Waits, Bert. Hand-Held Calculators in the Freshman Mathematics Classroom. American Mathematical Monthly 83: 731-733; November 1976.

A college-level remedial mathematics course is described in which students were required to use calculators as a part of their course work.

*Lim, James K. and Tseng, M.S. The Electronic Pocket Calculator--A Significant Factor in Students' Performance of Pharmaceutical Calculations? American Journal of Pharmaceutical Education 40: 14-16; February 1976.

The possible subtle influence of calculators in the routine evaluation of the arithmetical proficiency of students is noted. Results of a study with a class of 71 first-year professional pharmacy students taking a two-credit pharmaceutical calculations course are interpreted.

Lorthup, Larry L. and Jones, Edwin C., Jr. Pocket Calculators in Engineering Education. In Teaching Aids in the College Classroom, Lawrence P. Grayson and Joseph M. Biedenbach, editors. Washington: American Society for Engineering Education, 1975. ERIC: ED 113 173. 137 pages.

Questions about the use of calculators in the engineering classroom are discussed, a freshman-year course in engineering computation emphasizing calculators is described, and features needed for calculators used in engineering are listed.

Miller, Paul E. How to Use the HP-45 Calculator as a Stopwatch or Elapsed-Time Indicator. Popular Electronics 9: 67: June 1976.

Directions are given for gaining access to the clock function in the Hewlett-Packard 45 calculator. A method of using the function for timing and storing elapsed times of up to nine separate events is described. The accuracy of the HP-45 as a timer is discussed.

Miller, Robert P. Some Thoughts on Traditional Concepts in Teaching Accounting. Journal of Business Education 51: 35-36; October 1975.

Reasons for and against the use of calculators in an accounting class are given, and a compromise solution is suggested.

*Nichols, Warren Elmer. The Use of Electronic Calculators in a Basic Mathematics Course for College Students. (North Texas State University, 1975.) Dissertation Abstracts International 36A: 7010; June 1976.

No significant differences were found when achievement and attitude of college basic mathematics students in classes using the calculator were compared to those of students in non-calculator basic mathematics classes. Among students using calculators, those having higher aptitudes in mathematics showed significantly higher achievement and attitude scores than students having lower aptitudes.

*O'Loughlin, Thomas. Using Electronic Programmable Calculators (Mini-Computers) in Calculus Instruction. American Mathematical Monthly 83: 281-283; April 1976.

An experiment in which a minicomputer was used as an instructional aid in a calculus classroom and as a laboratory device for students is described.

*Roberts, Dennis M. and Glynn, Shawn M. Effects of Calculation Method and Task Difficulty on Statistical Problem Solving. Unpublished paper. The Pennsylvania State University. April 1977.

In a pilot study (October 1976), 48 college students were randomly assigned to manual (no calculator), basic, or advanced calculation conditions to work statistical problems. Calculator groups took less time and made fewer errors than the manual group. In a second study, 60 college students worked easy and hard statistical problems under one of the three calculation conditions. Results indicated that calculator usage reduced working time and errors, especially on hard statistical problems. Subjects in the calculator groups also expressed more positive attitudes about themselves and the problem solving tasks.

Schlaphoff, Carl W. CAI on a Programmable Calculator. MATYC Journal 9: 42-46; Winter 1975.

A procedure is described for presenting routine practice problems on a programmable calculator with attached teletype. The program uses a random number generator to write problems, gives feedback, and assigns grades according to the procedures outlined and flow-charted by the author.

Schmidt, Stanley A. Fourier Analysis and Synthesis with a Pocket Calculator. American Journal of Physics 45: 79-82; January 1977.

Two programs for performing Fourier analysis and synthesis with a Hewlett-Packard (HP-25) calculator are described.

Seymour, M.D. and Fernando, Q. Effect of Ionic Strength on Equilibrium Constants: The Use of a Pre-programmed of Programmable Pocket Calculator in the Laboratory. Journal of Chemical Education 54: 225-227; April 1977.

Shearer, Edmund C. Applications of a Programmable Calculator in a Freshman Laboratory. Journal of College Science Teaching 5: 244-245; March 1976.

The use of a programmable calculator for student experiments, grading of laboratory reports, and assigning accuracy and precision scores is described.

*Schuch, Milton Leonard. The Use of Calculators Versus Hand Computations in Teaching Business Arithmetic and the Effects on the Critical Thinking Ability of Community College Students. (New York University, 1975.) Dissertation Abstracts International 36A: 4299; January 1976.

Two classes of community college business mathematics students used calculators in the classroom, while two other business mathematics classes at the same school followed the same curriculum without using calculators. There were no significant differences between groups on standardized tests of arithmetic achievement, mathematical reasoning, and critical thinking abilities.

Snadden, R.B. and Runquist, O. Simulated Experiments. Education in Chemistry 12: 75, 77; May 1975.

An experiment is presented in which a programmable calculator is employed as a data-generating system for simulated laboratory experiments. The example used is a simulated conductimetric titration of an aqueous solution of HCl with an aqueous solution of NaOH.

*Sosebee, Jackson B., Jr. and Walsh, Lola Mae. Pocket Calculators and Test Scores in Introductory Chemistry. Journal of College Science Teaching 4: 324; May 1975.

Presented is a brief description of a study done to assess the impact of the use of calculators during examinations, showing that the use of the calculators did play a major role in chemistry grade determination.

Tufte, Edward R. Sophisticated Electronic Pocket Calculators: Theory and Practice for the Consumer and User. Creative Computing 3: 34-35; May-June 1977.

Nine principles to help the consumer and user of sophisticated pocket calculators are identified.

Utterback, Allen C. Discovery via Calculators. MATYC Journal 9: 22-29; Spring 1975.

Uses of calculators and computers in the college classroom are described, a philosophy about their use is discussed, and several problems (especially amenable to use of a computer with plotting facility) are presented.

Vincent, William John. Elementary Statistics in Physical Education. Springfield, Illinois: Charles C. Thomas, November 1, 1976. ERIC: ED 131 066. 193 pages.

This statistics text includes a review of the four basic mathematics operations, square roots, and algebraic equations, and points out how the calculator can be used to assist the statistics student.

*Zepp, Raymond Andrew. Reasoning Patterns and Computation on Proportions Problems, and Their Interaction with the Use of Pocket Calculators in Ninth Grade and College. (The Ohio State University, 1975.) Dissertation Abstracts International 36A: 5181; February 1976.

One hundred seventy ninth graders and 198 college freshmen were classified as having high, middle, or low ability in solving proportions. Half the students in

each ability group were given calculators to use while working on a programmed unit in linear interpolation, while the rest of the students could only use paper and pencil for their computations. No significant differences were found between performances of students using calculators compared to those not using calculators, nor was there any significant interaction of use of calculators with ability to solve proportions. The hypothesis that students could understand a proportional train of thought better if the barrier of computation were removed was not borne out.

Papers Presented at the Association for Educational Data Systems Annual Convention (Phoenix, Arizona). May 1976. ERIC: ED 125 658. 93 pages.

Included among papers on the use of computers and electronic equipment in instruction is one paper discussing the use of programmable, hand-held calculators for calculus instruction.

This publication was prepared pursuant to a contract with the National Institute of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official National Institute of Education position or policy.
August 1977: Revision of Reference Bulletin No. 5, April 1977.

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Bulletin No. 14
Update: December 1977

Instruction with Hand-Held Calculators, K-12

Articles

Adkins, Steve S. Easy Fractional Conversion from/to Base 10 to/from Any Lower Base. Calculators/Computers 1: 63-66; October 1977.

Shortcuts for converting base ten integers to or from other lower-base integers are discussed in terms of the key strokes used on a four-function calculator. A student worksheet with accompanying answer sheet is included.

Albrecht, Bob. Calculators for Beginners. Calculators/Computers 1: 75-82; October 1977.

This is the second article in a series about simple, four-function calculators and elementary concepts in computer programming. This article covers multiplication, powers, and a multiplication game. Student exercises and answers are provided.

Garner, Lou. The Great Guessing Game. Popular Electronics 11: 85-93; January 1977.

Predictions involving the production of calculators in 1976 are verified, and new predictions for 1977 are made.

Jesson, David and Kurley, Frank. Specifications for Electronic Calculators. Mathematics Teaching 70: 42-43; March 1975. Reprinted in Mathematics Teacher 69: 80-82; January 1976.

Features, listed in order of preference, are discussed: natural-order arithmetic, floating point, underflow, constant key to operate on all four operations, eight-digit display, fingertip-size keys, rechargeable batteries with alternative plug-in operation, and clear-entry key.

Kaufman, Burt A. and Haag, Vincent H. New Math or Old Math? -- The Wrong Question. Arithmetic Teacher 24: 287-292; April 1977.

Four examples are given to show how children can be involved in intellectual experiences in mathematics. The fourth example describes an activity which uses number properties to extend the range of a calculator beyond its eight-digit display capabilities.

Litwiller, Bonnie H. and Duncan, David R. Calculations You Should Never Make Without a Minicalculator. Mathematics Teacher 70: 654-656; November 1977.

Ten problem-solving activities are presented which involve large numbers and real data, written for use with a calculator.

Munson, Howard R. Your District Needs a Policy on Pocket Calculators. Arithmetic Teacher 25: 46; October 1977.

School systems are urged to formulate a system-wide policy that will govern the use of calculators in the classroom. Ten questions to consider when developing such a policy are given.

Oglesby, Alice. A Calculator Crossword Puzzle. Calculators/Computers 1: 38-39; October 1977.

The words for this crossword puzzle are found by working computational problems on a calculator and reading the inverted display.

Oglesby, Mac. Frogs. Calculators/Computers 1: 5-8; October 1977.

Rules to play the game "Frogs" on an SR-52 programmable calculator are given. Flowcharts, a program listing, and a sample game are included.

Rogers, Jean B. Introducing Calculators to Your Class. Calculators/Computers 1: 57-59; October 1977.

A set of steps for introducing calculators to elementary school children is suggested.

Rosenblum, Arlene. Should Your Child Use a Calculator? Good Housekeeping 184: 224; February 1977.

Advantages of allowing children to use calculators in school are discussed briefly. Features to look for in selecting a calculator are described.

Simons, S. What Can Be Done with a Simple Hand Calculator. American Journal of Physics 10: 1007; October 1977.

Procedures for evaluating three algebraic expressions using a four-function calculator are given.

Thiagarajan, Sivasailam. 4 Games for 4-Function Calculators. Creative Computing 3: 126-128; September-October 1977.

Four games which can be played by both children and adults are given, for use with a four-function calculator.

Wahl, M. Stoessel. Simpson's Rule for Volume and the Hand Held Calculator. Calculators/Computers 1: 23-29; October 1977.

Simpson's rule for calculating volume is discussed and applied to finding the volume of several solids, with four student worksheets provided. The calculator is mentioned as a computational aid.

Research on Hand-Held Calculators, K-12

Bolesky, Edward Michael. The Influence of Electronic Hand-Held Calculators on Cognitive Achievement in Chemistry. (Boston College, 1977.) Dissertation Abstracts International 38A: 1319-1320; September 1977.

Eighty college-preparatory CHEM Study chemistry students were randomly assigned to either a calculator group or a non-calculator group for this one-semester study. The calculator group used calculators during class sessions to perform calculations for homework, laboratory exercises, and chapter tests and quizzes. No significant differences in chemistry achievement were found between the two groups on the posttest measures.

Boling, Mary Ann Neaves. Some Cognitive and Affective Aspects of the Use of Hand-Held Calculators in High School Consumer Mathematics Classes. (The Louisiana State University and Agricultural and Mechanical College, 1977.) Dissertation Abstracts International 38A: 2623-2624; November 1977.

Over a period of 19 weeks, a group of 51 twelfth-grade consumer mathematics students used calculators to perform all computations while a group of 43 students used traditional paper-and-pencil methods. No significant differences in mathematical problem-solving achievement or in attitude toward mathematics were found between the two groups. Strong positive attitudes toward the use of calculators in the classroom were found.

Majumdar, Badiul Alam. Innovations, Product Developments and Technology Transfers: An Empirical Study of Dynamic Competitive Advantage: The Case of Electronic Calculators. (Case Western Reserve University, 1977.) Dissertation Abstracts International 38A: 2926; November 1977.

The electronic calculator industry was studied with respect to international trade and transfer of technology.

Nielsen, Thomas G. and Loiacono, Ronald. Report of Evaluation Plan and Data on K-1 Materials of Elementary Mathematics Concepts with Calculators™ Program. Dallas: Texas Instruments Learning Center, 1977. (Available from Gerald Luecke, Manager, Educational Products Development, Texas Instruments, Inc., P. O. Box 5012, Dallas, Texas 75222)

This is the report by two "outside evaluators" of the kindergarten and grade 1 program developed by Texas Instruments.

Tashjian, Richard Haig. A New Technique for Evaluating Consumer Preferences with Application to Calculator Product Characteristics. (New York University, Graduate School of Business Administration, 1977.) Dissertation Abstracts International 38B: 1789; October 1977.

A model was developed to estimate the probabilities of purchase associated with various products within a category. The technique was piloted using the product category of hand-held calculators.

Books

Bitter, Gary G. Calculator Power, Books 1-6. St. Paul, Minnesota: EMC Corporation, 1977.

DeMent, Gloria. Calculator Capers: An Introduction to the Calculator for Primary Grades. Englewood Cliffs, New Jersey: Prentice Hall Learning Systems, Inc., 1977.

Judd, W. Dogfight and More Games Calculators Play. New York: Warner Books, 1977.

Moursund, David. Calculators, Computers, and Elementary Education, for Teacher Education. Salem, Oregon: The Math Learning Center, 1977.

Råde, Lennart and Kaufman, Burt A. Adventures with Your Hand Calculator. St. Louis, Missouri: CEMREL, Inc., 1977.

Råde, Lennart. Take a Chance with Your Calculator. Forest Grove, Oregon: Dilithium Press, 1977.

Schlossberg, Edwin and Brockman, John. The Kid's Pocket Calculator Game Book. New York: William Morrow, 1977.

Schlossberg, Edwin and Brockman, John. The Pocket Calculator Game Book #2. New York: William Morrow, 1977.

Schwob, P. R. How to Use Pocket Calculators. New York: Petrocelli/Charter, 1976.

Vervoort, Gerardus and Mason, Dale. Calculator Activities for the Classroom (also Teacher's Resource Book). Toronto: Copp-Clark Publishing Co., 1977.

Number Sense and Arithmetic Skills. Palo Alto, California: Creative Publications, 1977.

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December 1977: Additions to Bulletins issued in August 1977.

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Bulletin 15
Update: June 1978

Instruction with Hand-Held Calculators, K-12

Aidala, Gregory. Calculators: Their Use in the Classroom. School Science and Mathematics 78: 307-311; April 1978.

The use of 15 calculators to promote problem-solving skills in an eighth-grade class is described. Suggestions and recommendations are included.

Aidala, Gregory and Rosenfeld, Peter. Calculators in the Classroom. Mathematics Teacher 71: 434-435; May 1978.

The use of calculators in an eighth-grade class is described, with an exercise on volume cited.

Albrecht, Bob. Calculators for Beginners. Calculators/Computers 2: 61-66; January 1978.

This is the fourth installment of a "teach yourself" style workbook; it introduces mixed operations.

Albrecht, Bob. Calculators for Beginners. Calculators/Computers 2: 91-96; March 1978.

The change sign key is introduced in this series of workpages.

Albrecht, Bob. Calculators for Beginners. Calculators/Computers 2: 23-28; April 1978.

A calculator version of the game Krypto is presented.

Beare, Richard and New, Peter J. Programmable Calculators for Elementary Physics Teaching. Physics Education 12: 424-426; November 1977.

Operating characteristics and features of programmable calculators are compared.

Bell, Max. Calculators in Secondary School Mathematics. Mathematics Teacher 71: 405-410; May 1978.

The effects of calculators on education, including discussion of potential strengths and weaknesses, are described. Specific suggestions for needed curriculum development are presented.

Bell, Frederick H. Can Computers Really Improve School Mathematics? Mathematics Teacher 71: 428-433; May 1978.

This discussion on the role of computers in mathematics classes points out

that "many of the teaching and learning activities that were enhanced by computers in schools during the 1970s can now be carried out with relatively inexpensive calculators."

Billstein, Rick and Lott, Johnny W. When Does a Fraction Yield a Terminating Decimal? Calculators/Computers 2: 15-19; January 1978.

A two-hour module used in a Calculator Usage in Elementary Schools class for teachers is presented; it is appropriate for use in grades 7 and 8. Using worksheets, students convert fractions to decimals, do the prime factorization of the denominator, and find patterns formed by the denominator of the fractions that are terminating decimals (using any four-function calculator).

Bourjaily, Bill and Radachy, Marc. Mathematics by Calculator. Berea, Ohio: Berea City School District, 1977. Xerox copy.

This year-long course for Mathematics 9-10 is designed to assist students who have had difficulty in mathematics as well as those who are unmotivated. Computational skills are applied in practical situations. Number, operation, space, symbolism, relation, proof, and approximation concepts are included as well as skills in computation with whole numbers, fractions, and decimals.

Bright, George. Ideas. Arithmetic Teacher 25: 28-32; February 1978.

Calculators may be used in solving pattern-recognition problems.

Clyde, Donald. Recycle the Tin Can Problem. Calculators/Computers 2: 35-44; February 1978.

A worksheet specifically for use with calculators is included in the presentation of the problem.

Consumer Reports. Two Compact Calculators with Long Battery Life. Consumer Reports 42: 561; October 1977.

Two calculators using long-life batteries (2000 hours) were rated.

Consumer Reports. Pocket-Sized Solar Power? Just Expensive Gadgetry. Consumer Reports 42: 620; November 1977.

Two solar-powered calculators were rated.

Consumers' Research Magazine. Electronic Calculators. Consumers' Research Magazine 60: 175-177; October 1977.

Ten calculators are rated, including two printing calculators. Display characteristics and types of calculators are also briefly described.

Consumers' Research Magazine. Some More Calculators. Consumers' Research Magazine 60: 33-36; November 1977.

Five calculators are rated--1 four-function, 1 specialized, and 3 scientific calculators.

Crothamel, David A. A Calculator Project for Elementary Functions and Statistics Classes. Calculators/Computers 2: 79-85; March 1978.

This project, which can be carried out in any junior or senior mathematics class with at least one calculator with an exponential function, is described in terms of the elementary function aspect, the statistical aspect, data, fitting the curve, and a summary.

Davidson, James J. Calculators as Recreation. Calculators/Computers 2: 17-18; March 1978.

A reason for the popularity of calculator games is discussed: "a calculator game, then, is a simple but challenging vehicle by which a quantitative mind can play directly with the objects of its affection--numbers--regardless of the amount of mathematical skill."

Drake, Paula M. Calculators in the Elementary Classroom. Arithmetic Teacher 25: 47-48; March 1978.

Using calculators to check work is discussed.

Ducharme, Robert. Computers (and Students!) Need Explicit Notation. Mathematics Teacher 71: 448-451; May 1978.

Examples of notational problems are cited, to point out the need for "a complete and consistent set of explicit operators."

Giese, Madeline. What's Up with Those Calculators in the Classroom? Part 1. Calculators/Computers 2: 67-70; January 1978.

This report lists arguments and attitudes resisting and favoring the use of calculators in the classroom, curriculum comments from articles, and the author's reactions.

Giese, Madeline. What's Up with Those Calculators in the Classroom? Part 2. Calculators/Computers 2: 55-59; February 1978.

A summary of uses of calculators and sources of information and materials are given.

Goodhue, Joseph F. Calculator Crossword Puzzle. Mathematics Teacher 71: 279-282; April 1978.

Students are to use calculators to demonstrate their knowledge of the correct order of operations for a given mathematical expression in doing a worksheet and a crossword puzzle.

Hallerberg, Arthur E. Squaring the Circle--For Fun and Profit. Mathematics Teacher 71: 247-255; April 1978.

Some historical approaches to finding the area of a circle are presented, with calculators suggested for use in solving some of the problems.

Herron, J. Dudley. High School Forum. Journal of Chemical Education 54: 628; October 1977.

The uses of programmable calculators in secondary school classes are discussed, including grading, laboratory, exercises, computing T-scores, and a quantitative approach to chemical equilibrium.

Hiatt, Arthur A. Finding Areas Under Curves with Hand-Held Calculators. Mathematics Teacher 71: 420-423; May 1978.

The method of inquiry is applied to find the area of a circle using the calculator.

Hobbs, Billy F. and Burris, Charles H. Minicalculators and Repeating Decimals. Arithmetic Teacher 25: 18-20; April 1978.

An algorithm for generating on any calculator as many digits as desired in the decimal representation of the rational number N/D is given in detail.

Huff, Darrell. Calcu-Letter. Popular Science 211: 23-24; November 1977. 212: 8; January 1978. 212: 6; March 1978. 212: 40; May 1978.

This bimonthly column presents some problems, some hints on how to use a calculator, and some comments on particular calculators.

Johnston, David W. Reactions (to The Tin Can Problem). Calculators/Computers 2: 45-47; February 1978.

A programmable calculator program to solve the equations in the Tin Can problem (Clyde, 1978) is presented in this letter.

Johnston, David W. Letters. Calculators/Computers 2: 82-83; April 1978.

Three programs for exercises in Scott (1978) are given in this letter.

Krause, Marina C. Stepcounter. Calculators/Computers 2: 26-28; January 1978.

A calculator is used as a counter in activities for levels 4-8 for determining students' paces per kilometer and relating the metric system to students' own lives.

Krist, Betty J. and Jewell, Wallace F., Jr. A New Look at $0^0$. Buffalo: State University of New York at Buffalo, 1978. Xerox copy.

Reasons for exploring $0^0$ are discussed, and then the role of calculators in examining the problem is presented.

Lander, Kathleen. Printing Calculators for Show-and-Save Records. Popular Science 212: 59-61; January 1978.

Characteristics of 20 printing calculators are presented and discussed.

Lappan, Glenda and Winter, Mary Jean. A Calculator Activity That Teaches Mathematics. Arithmetic Teacher 25: 21-23; April 1978.

A variation of Bingo is given, with directions for the calculator activity and extensions.

Lazarus, Mitchell. Reckoning with Calculators. National Elementary Principal 57: 71-77; January 1978.

Calculators in school need not cause decline in either practical skill or mathematical understanding. With the right curriculum materials, they can help bring about major improvements in mathematics education.

McCarty, George. Squares, Square Roots, and the Quadratic Formula. Calculators/Computers 2: 82-89; January 1978.

This article, a portion of Chapter 1 from Calculator Calculus, presents a repetitive method for approximating square roots using the calculator.

Michelow, Jaime S. and Vogeli, Bruce R. The New World of Calculator Functions. School Science and Mathematics 78: 248-254; March 1978.

The importance of functions is discussed and specific illustrations of the calculator as a function generator are presented.

Morris, Janet. More About Repeating Decimals. Calculators/Computers 2: 64-68; April 1978.

The investigation of decimal equivalents (Billstein and Lott, 1978) is extended with three problems.

Morris, Janet Parker. Problem Solving with Calculators. Arithmetic Teacher 25: 24-26; April 1978.

Activities using four-function calculators are classified by purpose: to explore number patterns, to discover relationships and develop concepts, to practice mental estimation, to reinforce inverse relationships, to solve application problems, to develop the "guess-then-check" technique, and for individual exploration and enrichment.

Moursund, David. Calculator Arithmetic. Calculators/Computers 2: 36-41; April 1978.

The calculator number system, underflow and overflow, calculator arithmetic, integer arithmetic, working with fractions, use of memory, and other memory-like features are discussed, with 11 exercises included.

Nicolai, Michael B. Sum of the Integers. Mathematics Teacher 71: 271-273; April 1978.

The calculator makes it feasible for students to find the sum of all n-digit whole numbers that may be formed from an n-digit whole number.

Ockenga, Earl and Duea, Joan. Ideas. Arithmetic Teacher 25: 28-32; May 1978.

Four worksheets are given in which the calculator can be used to provide practice on estimation.

Rising, Gerald R.; Krist, Betty J.; Roesch, Carl; and Jewell, Wallace. Using Calculators in Mathematics. National Institute of Education Contract No. 400-78-0013. Buffalo: State University of New York at Buffalo, 1978. Xerox copy.

This preliminary set of materials, field-tested during 1977-78, incorporates the use of programmable calculators in the standard mathematics curriculum in grades 11 and 12. The first chapter makes students familiar with different kinds of calculators and teaches algebraic, AOS, RPN, and arithmetic calculator logics, as well as simple programming. The second chapter (thus far available) is on exponents and logarithms.

Rogers, Jean B. Using Calculators for Problem Solving. Calculators/Computers 2: 19-21; March 1978.

A unit is presented which specifies how the calculator can be used for two problem-solving techniques, trial-and-correction and make a table.

Schmalz, Rosemary. Calculator Capers. Mathematics Teacher 71: 439-442; May 1978.

An opportunity for students to discover numerical patterns is provided by three worksheets.

Schultz, James E. How Calculators Give Rise to a New Need for Skills in Algebra. School Science and Mathematics 78: 131-134; February 1978.

Illustrations are given of how doing certain algebraic manipulations prior to doing calculations can eliminate unnecessary storage of data, reduce the number of steps required to obtain an answer, and avoid data overflow.

Scott, Douglas E. Finding Roots with a Four-Function Calculator. Calculators/Computers 2: 77-81; January 1978.

The "repeat" capability of most four-function calculators is used in an algorithm to find any integral root of any number.

Smith, Gerald R. Repeating Decimals. Calculators/Computers 2: 57-61; March 1978.

Determining repeating decimals is examined in this article, with 17ths, 19ths, 23rds, 31sts, and 41sts suggested for exploration.

Toth, Frank S., Jr. Calculator Experiments for Junior High. Calculators/Computers 2: 69-73; April 1978.

Three experiments used with seventh graders are presented: finding quotient and remainder, listing 10 non-zero multiples of a given number, and stating which of the numbers 2 to 20 are factors of a given number.

Usiskin, Zalman. Are Calculators a Crutch? Mathematics Teacher 71: 412-413; May 1978.

That a crutch is a bad thing is questioned; use of the calculator as a useful crutch is illustrated.

Waits, Bert K. Using a Calculator to Find Rational Roots. Mathematics Teacher 71: 418-419; May 1978.

A method is given for approximating the nth root of any positive number with a four-function calculator with square root key and repeat multiplication capability.

Wavrik, John J. Finding the Klingon in Your Calculator. Calculators/Computers 2: 29-33; January 1978.

A calculator program for finding a Klingon spaceship is given.

Wavrik, John J. Comments and Teacher's Notes and Answers. Calculators/Computers 2: 74-76; February 1978.

Answers for Wavrik (January 1978) are given with comments.

Wavrik, John J. The Case for Programmable Calculators. Calculators/Computers 2: 63; April 1978.

Advantages of the calculator over the computer for certain uses are discussed.

Weaver, J. F. Calculators and Unary Operations. Project Paper 77-7. Madison: Wisconsin Research and Development Center for Cognitive Learning, December 1977. Xerox copy.

A rationale is given for the consideration of unary operations which can be facilitated by using calculators. Suggestions and illustrations of some ways to accomplish this at the pre-algebra level are given.

Weaver, J. F. A Monadic Module Alias a Unary Unit. Calculators/Computers 2: 29-36; April 1978.

This module is excerpted from material prepared for ongoing calculator explorations with a class of accelerated seventh-grade students. Greater attention is given to unary or monadic operations. Relationships and properties to be identified, suggestions for the teacher, calculator algorithms, and record sheets are provided.

Yates, Daniel S. Coping with Calculators in the Classroom. Curriculum Review 16: 207-209; August 1977.

This is the first of a two-part article; it considers the pros and cons of the use of calculators in the classroom, attempting to differentiate between the facts and assumptions about the problem. Important questions for research are identified.

Yates, Daniel S. Coping with Calculators. Curriculum Review 16: 280-283; October 1977.

This is the second of a two-part article on the controversy over the use of calculators in the classroom. The author points out the possible effective uses for the calculator and suggests guidelines for those who wish to incorporate it into their classroom approaches.

NCTM. Position Statements: Use of Minicalculators. Mathematics Teacher 71: 468; May 1978.

The 1974 NCTM Board of Directors' position statement on calculators is reprinted.

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Bulletin 16
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## Books on Calculator Applications

Beardslee, Edward C. Teaching Computational Skills with a Calculator. In Developing Computational Skills (Marilyn N. Suydam, editor). 1978 NCTM Yearbook. Reston, Virginia: National Council of Teachers of Mathematics, 1978.

Ways to use a calculator as an integral part of mathematics instruction in existing curricula are provided. Activities are proposed that will help children think about mathematics rather than merely push buttons.

Bitter, Gary G.; Engelhardt, Jon M.; and Wiebe, James. One Step at a Time. St. Paul, Minnesota: EMC Corporation, 1977.

This text, developed to help teachers learn a diagnostic/prescriptive approach, includes cross-references to pages in Calculator Power (Bitter, 1977.)

Chinn, William G.; Dean, Richard A.; and Tracewell, Theodore N. Arithmetic and Calculators: How to Deal with Arithmetic in the Calculator Age. San Francisco: W. H. Freeman & Co., 1978.

Immerzeel, George. Using Calculators in the Classroom. Ormond Beach, Florida: Camelot Publishing Co., 1976.

Irvin, Barbara B. (editor). Data Tasks for Exploring Math with DataMan. Dallas: Texas Instruments Learning Center, 1978.

McHale, Thomas J. and Witzke, Paul T. Calculation and Calculators. Reading, Massachusetts: Addison-Wesley Publishing Co., 1978.

Prigge, Glenn and Gawronski, Jane Donnelly. Calculator Activities. Big Spring, Texas: Math-Master, 1978.

Puzzles, pattern searches, problems, and a variety of other activities are included in this book.

Prigge, Glenn and Mauland, Lyle (editors). Activities for the Minicalculator. Minot: North Dakota Council of Teachers of Mathematics, 1978. (Available from: James Babb, Mathematics Department, Minot State College, Minot, North Dakota 58701; $5.00 prepaid.)

Sippl, Charles J. and Sippl, Roger J. Programmable Calculators: How to Use Them. Champaign, Illinois: Matrix Publishers, Inc., 1978.

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Bulletin 17
Update: June 1978

Research on Calculator Uses, K-12

Channell, Dwayne E. The Use of Hand Calculators in the Learning of Basic Multiplication Facts. Columbus: The Ohio State University, May 1978. Xerox copy.

This "informal study" investigated the effectiveness of using calculators as an immediate feedback device in learning some basic multiplication facts. One class of 26 second graders was given a pretest of 20 facts, with about five seconds allowed for each response. Seven days of classroom instruction by the regular teacher involved nine textbook pages plus activities using physical and pictorial models. Students also practiced for 8 to 10 minutes on 6 days, using calculators to check immediately their recall on each combination (but not using other materials). The set of 20 facts was given again. The mean increased from 6.37 to 12.16. The largest gain in recall occurred on those facts practiced on the calculator alone; the smallest gain was on those facts presented by the textbook alone.

Graeber, Anna O.; Rim, Eui-Do; and Unks, Nancy J. A Survey of Classroom Practices in Mathematics: Reports of First, Third, Fifth and Seventh Grade Teachers in Delaware, New Jersey, and Pennsylvania. Philadelphia: Research for Better Schools, Inc., 1977.

In a survey in 1977 of 1,343 teachers in grades 1, 3, 5, and 7, questions on calculator use were included. The percentage of teachers who had used calculators was: 3.9% at grade 1, 8.4% at grade 3, 19.4% at grade 5, and 25.6% at grade 7. In the first grade, calculators were used most frequently for drill; the next three most frequent usages were for checking, motivation, and remediation. Use of the calculator for drill decreased with grade level. Above first grade, the most frequent use was for checking, with motivation and word problems next most frequently reported uses.

Hopkins, Billy Lynn. The Effect of a Hand-Held Calculator Curriculum in Selected Fundamentals of Mathematics Classes. (The University of Texas at Austin, 1978.) Dissertation Abstracts International -- in press.

This study investigated the effects on achievement and attitude resulting from use of a calculator-based curriculum and calculators in ninth-grade basic mathematics (in which students were at least two grade levels behind in mathematics achievement). Twelve classes from three schools were randomly assigned to either calculator (n = 83) or non-calculator groups (n = 84). For four weeks, teachers used guides prepared by the investigator to teach estimation, computation, and problem solving using the four operations with whole numbers. One half of each group was randomly selected to take the posttest with calculators available, while the other half did not have calculators. Data were analyzed by analysis of covariance. Students using

calculators in instruction scored as well in computation and significantly better in problem solving as their peers not using calculators. Attitudes were not significantly different. Students using calculators on the posttest did significantly better in both computation and problem solving than students not using calculators.

Kasnic, Michael James. The Effect of Using Hand-held Calculators on Mathematical Problem-Solving Ability Among Sixth Grade Students. (Oklahoma State University, 1977.) Dissertation Abstracts International 38A: 5311; March 1978. (Order No. 7801276)

Sixth-grade students from four randomly selected schools in a suburban school district were assessed on problem-solving ability and placed in a low, average, or high ability group. Ten students were randomly selected from each group at each school; schools were randomly assigned to one of four treatments: using calculators to practice problem solving; using calculators to practice problems and on the posttest of problem solving; practice on problems with paper and pencil only; or a control group. Nine 50-minute sessions of practicing problem solving comprised the treatment period. The calculator groups did not complete significantly greater numbers of practice problems than the non-calculator group, nor did groups differ on the number of correct responses. No significant differences were found between low and high ability groups.

Palmer, Henry B. A. Minicalculators in the Classroom--What Do Teachers Think? Arithmetic Teacher 25: 27-28; April 1978.

A survey of leadership personnel in Los Angeles County is reported; although a wide range of reactions was found, on the whole teachers seemed favorable to the idea of calculators in the classroom.

Royce, George and Shank, James. Calculators in the Classroom? Science Teacher 44: 23-25; October 1977.

The results of a student attitude survey among junior high school students who had been allowed to use calculators to check mathematics computations are reported. Significant preference for using calculators in the classroom was displayed.

Rudnick, Jesse. Pocket Sized Calculators Versus Seventh Grade Math Students. Philadelphia: Temple University, May 1978. Multilith copy.

Approximately 700 seventh-grade students in two schools were randomly assigned either to calculator or control groups. Each of six teachers taught two experimental and two control classes, using the regular textbook. Students were "on their own" as to how and when they used calculators; they kept logs of when and for what operations calculators were used. No significant difference in computational skills was found between groups. Attitudes of students in both groups varied little. Parental attitudes, however, changed: while 50 percent opposed the use of calculators at the outset, only 33 percent were opposed at the end. At the start, 49% felt that their children would become highly dependent on the machine, while at the end this number dropped to 22%.

Weiss, Iris R. Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education. Final Report, National Science Foundation Contract No. C7619848. Research Triangle Park, North Carolina: Research Triangle Institute, Center for Educational Research and Evaluation, March 1978.

A national survey conducted for the National Science Foundation included questions about the extent of use of calculators in schools. For four grade ranges, the percentage of schools having calculators was: K-3, 28%; 4-6, 36%; 7-9, 49%; 10-12, 77%. Rural schools are as likely as suburban schools to have calculators, and both are significantly more likely to have them than schools in small cities or urban areas. The percentage of mathematics classes using calculators increased with grade level: K-3, 6%; 4-6, 14%; 7-9, 30%; 10-12, 48%. Most K-3 teachers indicated that calculators are not needed; in 4-6, 44% indicated that they were not needed, while 39% needed them but did not have them; for 7-9, the comparable percentages were 42% and 28%; for 10-12, 33% and 18%.

Williams, David and Tobin, Alexander. Philadelphia Minicalculator Program. Mathematics Teacher 71: 471-472; May 1978.

Results from a survey of 415 secondary teachers are briefly summarized. Guidelines were developed and a booklet for teachers prepared. The effect of using calculators and the curriculum supplement has been studied in five schools.

Yvon, Bernard R. and Downing, Davis A. Attitudes Toward Calculator Usage in Schools: A Survey of Parents and Teachers. School Science and Mathematics 78: 410-416; May-June 1978.

Two-hundred-fifty parents and teachers of grades K-9 replied to a 12-item questionnaire about the use of calculators. They were increasingly more accepting of calculator use as grade level (3-6, 7-8, 9-12) increased, with teachers significantly more favorable than parents at the two lower levels. Both groups were moderately negative about the use of calculators for homework and about whether skills with calculators will be essential to future success. They were accepting of the use of calculators for enrichment, motivation, and games. While moderately negative replies were given about the use of calculators to replace paper-and-pencil skills, they were very accepting of the use of calculators along with paper-and-pencil computation.

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Bulletin 18
Update: June 1978

## References on Calculators, Post-Secondary Level

Ball, John A. Algorithms for RPN Calculators. New York: Wiley, 1977.

Eisberg, Robert M. Applied Mathematical Physics with Programmable Pocket Calculators. New York: McGraw-Hill, 1976.

Phillips, R. F. Simple Gravitation Using a Programmable Pocket Calculator. Physics Education 12: 360-363; September 1977.

Described is the calculation (with a programmable calculator) of the potential of the earth's gravitational field strength and the energies of satellites in orbit around the earth.

Roberts, Dennis M. and Glynn, Shawn M. A Comparison of Numerical Problem Solving Under Three Types of Calculation Conditions. Calculators/Computers 2: 71-74; January 1978.

The purpose of this study was to examine the relative magnitude of benefit that accompanies use of calculators compared to hand computation. Forty-eight students in an introductory statistics course were randomly assigned to three treatment groups: (1) Manual--all computation by hand; (2) Basic Machine--use of a four-function calculator without memory or square root key; or (3) Advanced Machines--use of calculators with either two memories or square root. They were given a test with five routine sets of data and problems involving frequency distributions. Large differences were found between either of the machine conditions and the manual condition, but very little difference was found between the two machine conditions. The machine work was more than twice as efficient as calculation by hand.

Roberts, Dennis M. and Glynn, Shawn M. Numerical Problem Solution as a Function of Calculation Mode and Task Difficulty. Calculators/Computers 2: 69-73; February 1978.

This is the second in a series of studies designed to test the hypothesis that calculators facilitate problem solution by saving time and increasing accuracy. Sixty students in an introductory statistics course were involved; computational tests containing both easy and difficult statistical problems were used. Students were randomly assigned to manual, basic machine, or advanced machine conditions. The calculator groups were superior on measures of number correct, time, and efficiency scores and in attitude, with the two types of calculator groups not significantly different. Task difficulty was not significant, although there was a larger difference between performance on easy and difficult problems in the hand condition than in the machine condition.

Roberts, Dennis M. and Fabrey, Larry. Effects of Calculation Method, Amount of Prepractice and Instructional Work Set on Numerical Problem Solving. Calculators/Computers 2: 63-70; March 1978.

This study investigated the effect on computation performance of amount of prepractice and type of calculator, when students were told to work very fast versus very accurately. Sixty students in an introductory statistics course were randomly assigned to four treatments: basic machine, 2 or 5 prepractice trials; advanced machine, 2 or 5 trials. Half of each group worked under "fast" or "accurate" conditions. Amount of prepractice made no difference in number correct or in time required to work the problems. Students using the more advanced calculators needed only about half the time and had more correct answers. Time and accuracy were greater under the "accurate" condition. The advanced calculator group was significantly more efficient, as was the "fast" condition. On four of five attitude clusters, advanced calculator users were significantly more positive.

Roberts, Dennis and Lerner, Jackie. Computational Performance with Different Calculation Methods and Task Difficulties: A Repeat Investigation. Calculators/Computers 2: 74-77; April 1978.

One-hundred-two students in a beginning statistics course were randomly assigned to six conditions--use of handwork or of same or advanced calculators with either easy or difficult problems. The difficulty of the problems did not have a significant impact on the number of problems answered correctly. Time varied with type of calculator and difficulty level. Efficiency improved as sophistication level of the calculator improved. The group using the most sophisticated calculator expressed more positive attitudes than other groups did.

Roberts, Dennis M.; Seaman, Dennis; and Lerner, Jackie. Maximizing Effects of Calculators: A Study Varying Calculation Procedures, Difficulty of Tasks and Working Instructions. Calculators/Computers 2: 60-62; May 1978.

(Note: A copy of this fifth article in the set was not available for review.)

Sidran, Miriam. Computing the Balmer Wavelengths with a Hand Calculator. Physics Teacher 15: 423-434; October 1977.

A problem concerning the computation of hydrogen spectral line wavelengths, appropriate for computations with calculators having eight significant digits, is outlined for a general physics class.

Sippl, Charles J. and Sippl, Roger J. Programmable Calculators: How to Use Them. Champaign, Illinois: Matrix Publishers, Inc., 1978.

Smith, Jon M. Scientific Analysis on the Pocket Calculator. New York: Wiley, 1975. Second edition, 1977.

Calculator Programs. Sky and Telescope 54: 292; October 1977. 55: 102; February 1978. 55: 301; April 1978.

Selected programs of astronomical interest that have been written for calculators are noted. Topic and source are indicated.

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Bulletin 19
December 1978

## Instruction with Hand-Held Calculators, K-12

Albrecht, Bob. Calculators for Beginners. Calculators/Computers 2: 87-95; May 1978.

This seventh installment introduces the concept of memory and keys for manipulating numbers in memory.

Bartusiak, Marcia F. Calculatoritis. Science News 114: 347; November 1978.

The fear of over-reliance on the habit-forming calculator is discussed.

Billings, Karen and Moursund, David. Problem Solving Using Calculators. Calculators/Computers 2: 17-32; September/October 1978.

This is the first part in a serialized version of a book. It presents prefaces for teachers and for students, workpages for getting started, and worksheets on calculator letters, symmetries, order of operations, exponents, powers, and chaining.

Bitter, Cary G. Curriculum Considerations for Use of the Hand-Held Calculator. Calculators/Computers 2: 15-16; September/October 1978.

Different logic systems, rounding, converting fractions to decimals, decimal representation of a fraction, overflow, underflow, truncation, order of operations, "add-on" percent key, constant key, internal counting, division by zero, the negative sign, and consecutive operations are considered.

Bolduc, E. J. Using a Minicalculator to Find an Approximate Value for Pi. School Science and Mathematics 77: 689-691; December 1977.

Geometry and a hand-held calculator are used to find a value of pi accurate to five decimal places.

Davies, Pauline. Problem Solving Experiences with a Calculator. Calculators/Computers 2: 22-24; May 1978.

Suggestions for using calculators in solving word problems are presented for students in grade 5.

Dunlop, David L. Solitaire Mastermind with Programmable Hand Calculators. Calculators/Computers 2: 31-36; May 1978.

This game, programmed for an HP-25, can be modified for use with other programmable calculators. Using deductive logic, one or two players attempt to determine the code. Two programs (with variations) and a recording sheet are given.

Friedlander, Richard J. Efficient Algorithms for the Calculator. Mathematics Teacher 71: 614-618; October 1978.

A brief discussion of calculator logic is followed by descriptions of efficient algorithms for reciprocals, powers, and parentheses.

Goodrich, G. L.; Bennett, R. R.; and Wiley, J. K. Electronic Calculators for Visually Impaired Users -- Evaluation. Journal for Visual Impairment 71: 154-157; April 1977.

Calculators appropriate for the visually impaired are described and evaluated.

Gottheimer, Debra. More Power to the Calculator. Administrative Management 39: 34-44; July 1978.

Programmable calculators, including hand-held as well as desktop models, are described. Two charts are included, as well as five industry trends.

Grinstein, Louise S. Calculators in the Classroom: A Selected Bibliography. MATYC Journal 12: 238-242; Fall 1978.

Thirty-two references are included in this annotated listing. [Note: All have appeared on CIC bulletins.]

Henry, Loren L. An Invaluable Aid to Understanding Mathematics: The Hand-Held Calculator. School Science and Mathematics 77: 585-591; November 1977.

Instructional techniques are given for the use of calculators in finding prime numbers, solving trigonometric equations, and solving polynomial equations.

Huff, Darrell. Calcu-Letter. Popular Science 213: 22; July 1978. 56-57; September 1978. 62-63; November 1978.

This bimonthly column features a problem, solutions for previous problems, and some helpful hints (e.g., to save battery power, leave 1 instead of 0 on the display of continuously operating calculators).

Hutton, Lucreda A. Calculator Calisthenics. Arithmetic Teacher 276: 37; November 1978.

This briefly described activity is designed to improve retention of multiplication facts in a game format.

Jamski, William D. Earth and the Calendar. School Science and Mathematics 78: 517; October 1978.

The calculator can be used to compile a table comparing calendar years with planetary years.

Johnston, David W. Letters. Calculators/Computers 2: 12-13; September/October 1978.

A calculator program to solve for mean, standard deviation, and "normal curve" equation is given, to supplement Crothamel (1978).

Kessner, Arthur and Slesnick, Twila. Myths about Calculators in the Schools. Calculators/Computers 2: 78-81; September/October 1978.

Six concerns or fears about the use of calculators are discussed. Fear of dependence on calculators, the age at which calculators should be introduced, the roles of decimals and fractions, and the relationship of standard algorithms are included.

Koller, E. Z. and Mulhern, T. J. Use of a Pocket Calculator to Train Arithmetic Skills with Trainable Adolescents. Education and Training of the Mentally Retarded 12: 332-335; December 1977.

This report on a study with mentally retarded children is also reported in the Journal for Special Education of the Mentally Retarded, Winter 1977.

Krause, Marina C. The Calculator Plot. Calculators/Computers 2: 15-21; May 1978.

Two worksheets are presented, designed to use the calculator in solving problems with decimal fractions and graphing the solutions to discover mystery pictures.

Lichtenberg, Donovan R. Minicalculators and Repeating Decimals. Mathematics Teacher 71: 524-530; September 1978.

The calculator is used to determine repeating decimals; several theorems and examples are provided.

Lieblich, Gerald S. Pros and Cons of the Handheld Calculator. MATYC Journal 12: 199-203; Fall 1978.

Arguments for using or not using calculators are presented through comments on various articles and research studies.

Maor, Eli. This History of Pi on the Pocket Calculator. Journal of College Science Teaching 6: 97-99; November 1976.

Historical information on pi is presented in the context of a classroom experience using calculators to calculate pi.

Maor, Eli. A Children's Summer Course with the TI-57 Programmable Calculator. [Article submitted for publication; copy available at CIC.]

This is the description of the special six-week summer mathematics course offered in Eau Claire, Wisconsin for upper elementary and junior high school children. It was designed as an enrichment program to enhance interest and motivation; thus, it stresses ideas and concepts, rather than techniques and rote learning. Thirty-four students participated in two sections, ages 8-11 and ages 12-15. The syllabus for the course is included with a detailed description of how the topics were taught.

Miller, William A. and Hazekamp, Donald W. Calculator Graphing. Mathematics Teacher 71: 759-762; December 1978.

Three worksheets provide experiences in using calculators to compute squares, reciprocals, and square roots, plus rounding numbers to the nearest hundredth, plotting points, and drawing graphs.

Morgan, Raymond V. and Warnock, Tony T. Derivatives on the Hand-Held Calculator. Mathematics Teacher 71: 532-537; September 1978.

Some of the problems that arise in the use of calculators to illustrate derivatives are discussed, along with illustrations of numerical differentiation techniques.

Reubens, Arthur. Tracking Down Equation Roots. Machine Design 50: 120; August 1978.

A program written for an HP-55 calculator is given.

Schmalz, Rosemary. Calculators: What Difference Will They Make? Arithmetic Teacher 26: 46-47; December 1978.

Changes in emphasis on certain algorithms which the calculator makes feasible are discussed.

Schultz, James E. Using a Calculator to Do Arithmetic in Bases Other Than Ten. Arithmetic Teacher 26: 25-27; September 1978.

Many examples are provided in this presentation of using a calculator to perform operations in non-decimal bases.

Smith, Susan, Calculating Order. Mathematics Teacher 71: 519-522; September 1978.

Worksheets provide a calculator experience developing and reinforcing the concept of order of operations, for students in grades 7-10.

Stover, Stephen L. and Spikell, Mark A. The Role of Programmable Calculators and Computers in Mathematical Proofs. Mathematics Teacher 71: 745-750; December 1978.

Since numerous possibilities can be examined in a relatively short period of time, calculators and computers are powerful data-gathering instruments. How they can be used in proofs is explored with a simple problem from number theory.

Spero, Samuel W. Calculators and Computers: Graphical Addition. Calculators/Computers 2: 87-90; Seatember/October 1978.

The computer is used to generate a different problem set for each student; students then use calculators to solve these problems; finally, the computer generates the solution set for each student's problems. Graphical addition problems are used as examples.

Teitelbaum, Eli. Calculators for Classroom Use? Arithmetic Teacher 26: 18-20; November 1978.

Letting instruction focus on problem solving rather than computation alone is the point of this article. How calculators can be used to advantage is described through four illustrations, with comments on checking and on cheating.

Toth, Frank S., Jr. Calculator Experiments for Junior High (continued). Calculators/Computers 2: 69-73; May 1978.

This article, a continuation of one in the April 1978 issue, presents one experiment for determining the GCF and one for determining the LCM, using calculators.

Toth, James. Understand Electronic Math. Science Digest 84: 69-74; August 1978.

Base two, calculator logic, adding, and other operations are discussed.

Walton, Stephen. Electronic Mini-Marvels: Big Performance in Tiny Packages. Popular Mechanics 150: 93-95, 210-212; October 1978.

Over a dozen electronic devices are described, including several calculators.

Wavrik, John J. Programmable Calculators for Elementary School Students. Calculators/Computers 2: 44-47; September/October 1978.

Activities for students in grades 4-6 who show exceptional interest in mathematics are given in this first in a series of articles. The basic operations are programmed for the HP-25 calculator.

Wavrik, John J. Shooting the Klingon in Your Calculator. Calculators/Computers 2: 62-64, 92; September/October 1978.

A program for the HP-25 calculator is given, to extend the activity presented by Wavrik in January 1978.

Weaver, J. F. Some Monadic/Dyadic Combos. Calculators/Computers 2: 79-83; May 1978.

This unit is an extension of an article in the April 1978 issue. Reference sheets, record sheets, and directions are included for students to focus on monadic/dyadic operations.

Weaver, J. F. Calculators and Polynomial Evaluation. Madison: Wisconsin Research and Development Center for Individualized Schooling, The University of Wisconsin, July 1978. ERIC: SE 024 436.

The intent of this paper is to suggest and illustrate how hand-held calculators, especially nonprogrammable ones with limited data-storage capacity, can be used to advantage by students in one particular aspect of work with polynomial functions. The basic mathematical background upon which calculator application is built is summarized. Along with one calculator algorithm for polynomial evaluation that is relatively independent of calculator type, eight other algorithms that illustrate a variety of calculator types, characteristics, and features are given.

Weldert, R. W. Programmable Pocket Electronic Calculators in the Classroom. Journal of Chemical Education 54: 628: October 1977.

The use of calculators in grading and in laboratory exercises is noted.

Yee, Jose. The Problem Corner. Calculators/Computers 2: 86; September/October 1978.

An exploratory activity for finding roots of positive rational numbers is presented.

Zinn, Karl L. Speak & Spell, Spelling B. Creative Computing 4: 60-61; September/Octboer 1978.

Two electronic spelling machines are described, with some comments on calculators included in the discussion.

The Electronic Calculator in Remedial Mathematics. In Mathematics: Ideas for Strengthening Mathematical Skills. Albany, New York: State Education Department, 1978. ERIC: SE 024 566.

A brief section indicates that calculators have a role to play in mathematics instruction, but care must be taken that the structure of algorithms is not hidden. A set of four problems is provided to illustrate a worthwhile use of calculators.

Low Priced Calculators. Consumers' Research Magazine 61: 21-25; September 1978.

Memory, parentheses, display characteristics, and battery life are discussed; eleven calculators are rated.

1978 Buying Guide to Electronic Calculators. MAYTC Journal 12: 229-235; Fall 1978.

This is an excerpt from the report by Buyers Laboratory, noting features, programming capability, and other factors for a wide variety of calculators.

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## Books on Calculator Applications

Billings, Karen and Moursund, David. Problem Solving with Calculators. Salem, Oregon: The Math Learning Center, University of Oregon, 1978.

Donner, Michael and Matus, Lynn. Calculator Games. New York: Golden Press, 1977.

Hauser, Al W. Precalculated Fun. Phoenix, Arizona: Hauser Publications, 1978.

Madison, Arnold and Frotar, David L. Pocket Calculators: How to Use and Enjoy Them. New York: Thomas Nelson, Inc., 1978.

Mullish, Henry. How to Use a Pocket Calculator. New York: Arco Publishing Co., 1977.

Neufeld, K. Allen. Calculators in the Classroom. Monograph No. 5. Edmonton: Alberta Teachers' Association, 1977.

Rhodes, Bennie. Calculator Word Games. Milford, Michigan: Mott Media, 1977.

Calculators/Computers: The First Three Issues in Book Form. Menlo Park, California: Addison-Wesley, 1978.

Texas Instruments. Understanding Calculator Math. Dallas: Texas Instruments, Inc., 197 .

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December 1978

## Research on Calculator Uses, K-12

Eckmier, Janice Logan. An Investigation of the Use of Calculators with Low Achieving 4th Grade Students in Mathematics Achievement and Attitude. (University of Southern California, 1978.) Dissertation Abstracts International 38A: 7109; June 1978.

This study investigated the effects of hand-held calculators on achievement and attitudes toward mathematics at three levels of socioeconomic status. Six classes of low-achieving fourth graders participated from September to June, with an experimental and a control classroom at each of three SES levels. The experimental group used calculators in addition to the regular textbook, while the control groups used only the textbook. The experimental groups were assigned only 50 percent of the paper-and-pencil work completed by the control groups; the remaining time was used to check mathematics problems done by hand, as well as to do other calculator problems. No significant differences in achievement or attitude gains were found.

Laursen, Kay William. Use of Calculators in High School General Mathematics: A Study Comparing Achievement, Attitude, and Attendance of General Mathematics Students Who Used Calculators with Students Who Did Not. (Brigham Young University, 1978.) Dissertation Abstracts International 39A: 733; August 1978.

From five schools with 18 general mathematics classes which had classroom sets of calculators, nine classes were randomly assigned to use calculators while nine other classes used paper-and-pencil methods of computation. Analyses of variance and covariance using pre-posttest data indicated that greater gains were made by students using calculators. However, no significant differences were found in attitudes or attendance.

Lawson, Thomas James. A Study of the Calculator's and Altered Calculator's Effect upon Student Perception and Utilization of an Estimation Algorithm. (State University of New York at Buffalo, 1977.) Dissertation Abstracts International 39A: 647; August 1978.

Seventh-grade students from one junior high school were randomly assigned to use paper and pencil, a four-function calculator, or an altered calculator (with the function of the four operation keys masked). The four-day "interim work experience" was a 16-item computational task. Using analysis of variance, it was found that (1) computational ability correlated positively with ability to estimate, (2) the treatment had no effect on estimation skills, (3) students with low computational ability made the greatest number of errors when using calculators, and (4) altering the keyboard had no significant overall effect on ability to use calculators. Videotape analysis of students working indicated that many did not use estimation to verify answers. Interview information is also provided.

Lowerre, George F.; Scandura, Alice M.; Scandura, Joseph M.; and Veneski, Jacqueline. Using Electronic Calculators with Third and Fourth Graders: A Feasibility Study. School Science and Mathematics 78: 461-464; October 1978.

Instruction of three children for a ten-week period with place value, negative numbers, estimation, decimals, and other topics resulted in substantial gains in achievement on a standardized test. Topics to teach using calculators and implications for problem solving are discussed.

Prigge, Glenn and Langemo, Jan. Effects of Minicalculators on the Pre- and Co-Requisite Mathematical Skills of Intermediate School Children. Grand Forks: University of North Dakota Department of Mathematics, Summer 1978.

Thirty children from grades 3-6 in a summer school mathematics enrichment program in June 1978 were given experimenter-designed instructional materials designed to allow each student to work independently at his or her own level. Treatments were randomly designed. Pre- and posttests on multiplication, division, and attitudes were given, plus ten other tests during the experimental period. No significant differences were found on the three pre-post measures for students who (1) used calculators randomly in assignments or (2) were instructed that they must use calculator to complete assignments. On problems that students generally know how to work, the calculator did not seem to make much difference. However, if students knew the operation but could not carry out the mechanics of the algorithms, use of the calculator resulted in substantial mean gains.

Scandura, Joseph M.; Lowerre, George F.; Scandura, Alice M.; and Veneski, Jacqueline. Using Electronic Calculators with Children Ages 5-7, Four Mini-Experiments. School Science and Mathematics 78: 545-552; November 1978.

Four "mini-experiments" with small groups of children aged 5-7 are reported. Arithmetic computation with and without the calculator were compared; content of lessons is noted. General observations on motivation, independence, and other behaviors are reported, plus achievement inferences.

Toole, Betty A. Evaluation of the Effectiveness of Calculator Assisted Curriculum and Instruction in Ninth Grade General Mathematics Classes. Paper prepared for American Educational Research Association Meeting, 1979.

The use of a supplementary calculator-assisted program, used one day a week in six different junior high schools (N = 400) for ninth-grade general mathematics, was compared with non-use of calculators in that course. In the six-month period between pre- and posttesting, the experimental group gained 8 months more on the total test than the control group did. On subtests, the experimental group gained more than the control group in computation (7 months), concepts (5 months), and applications (1 year).

Wilson, Art Wendell. The Effects of the Hand-Held Calculator upon Achievement Test Scores of Elementary School Mathematics Students. (University of Montana, 1978.) Dissertation Abstracts International 39A: 2116; October 1978.

In three cities over a five-month period, fifth- and sixth-grade experimental classes, with teachers who had prior experience using calculators, were compared with classes denied use of calculators. Multiple analysis of variance of pre-posttest data indicated no significant differences in computation, concepts, applications, or teacher-made test scores. In two instances, males scored higher than females.

Hand Calculator. In Mathematics Objectives: Second Assessment. Denver, Colorado: National Assessment of Educational Progress, 1978.

One test booklet of approximately 25 exercises for calculators was administered at each age level tested in the second NAEP Mathematics Assessment. Students are required to use a four-function calculator after being given a minimal amount of instruction on how the calculator is used. Many of the exercises appear again in another booklet for the same age group, allowing for comparisons of performance with and without the calculator. Background information regarding extent of calculator use is also required.

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## References on Calculators, Post-Secondary Level

Aronofsky, Julius; Frame, Robert J.; and Greynolds, Elbert B., Jr. Programmable Calculators: Business Applications. New York: McGraw-Hill, 197 .

This book stresses basic computational skills and elementary and advanced programming techniques. It is tied in with the TI programmable calculators.

Cooper, Annette J. An Analysis of the Effect of the Use of Hand-Held Calculator on Attitude and Achievement in Selected College Algebra Classes. (Oklahoma State University, 1977.) Dissertation Abstracts International 39A: 85; July 1978.

At four two-year colleges, two control groups were conducted in spring 1975 and fall 1975, and two corresponding experimental groups in fall 1975 and spring 1976. Four teachers each taught a control group and, the following semester, an experimental group (using calculators). No significant differences in attitude or achievement were found between corresponding groups using or not using calculators.

Dunlop, David L. Solitaire Mastermind with Programmable Hand Calculators. Calculators/Computers 2: 31-36; May 1978.

This game, programmed for an HP-25, can be modified for use with other programmable calculators. Using deductive logic, one or two players attempt to determine the code. Two programs (with variations) and a recording sheet are given.

Dyce, Byron Alphonso. The Effect of Incorporating the Mini- or Hand-Held Calculator into a Community/Junior College Basic Mathematics Course. (The University of Florida, 1977.) Dissertation Abstracts International 39A: 43; July 1978.

Four basic mathematics classes at one college used calculators. They were administered pre- and posttests of achievement and attitude. A linear regression procedure indicated that "there was insufficient evidence to conclude that there was any particular advantage to using mini-calculators." No positive correlation was found between changes in achievement and in attitudes toward mathematics.

Eisberg, Robert M. Applied Mathematical Physics with Programmable Pocket Calculators. New York: McGraw-Hill, 197 .

Designed as a supplement to existing physics texts for the calculus-based course, this guide for using calculators with programmable capabilities presents a series of programs that enable students to treat key topics in physics.

Engelsohn, Harold S. Programming Programmable Calculators. Rochelle Park, New Jersey: Hayden Book Co., Inc., 1978.

Forbes, Milton L. Simulation of Natural Selection on the Programmable Calculator. Journal of College Science Teaching 8: 95-96; November 1978.

A model or game is described which enables students to experiment with equilibria and to trace rapidly gene frequency changes through time under postulated conditions of selection.

Gazdar, Abdus Sattar. A Short Program for Simpson's or Gazdar's Rule--Integration on Handheld Programmable Calculators. Two-Year College Mathematics Journal 9: 182-185; June 1978.

A flow chart and program for numerical integration are presented.

Geisinger, Kurt F. and Roberts, Dennis M. Individual Differences in Calculator Attitudes and Performance in a Statistics Course. Presentation at American Educational Research Association Meeting, 1978.

A 30-item instrument was developed to assess several dimensions of attitudes about calculators. Reliability and validity data were gathered on students in a college statistics course. Based on N=135, coefficient alpha was .874. Factor analyses identified three interpretable factors: trustworthiness of calculators, usefulness, and educational value. Correlations between attitude scores and both scourse grades and age were significant and positive. Females owned calculators more frequently than males, but there were no differences in attitudes based on sex or whether or not a student owned a calculator. Calculator ownership was positively related to age.

Greynolds, Elbert B., Jr.; Aronofsky, Julius S.; and Frame, Robert J. Financial Analysis Using Hand-Held Calculators. New York: McGraw-Hill, 197 .

Covering the application of a wide range of hand-held calculators to financial analysis problems, this book stresses problem identificantion and analysis techniques in approaching the mathematics of finance.

Grinstein, Louise S. Calculators in the Classroom: A Selected Bibliography. MATYC Journal 12: 238-242; Fall 1978.

Thirty-two references are included in this annotated listing. [Note: All have appeared on CIC bulletins.]

Hallden-Abberton, Patti and Waits, Bert K. The Programmable Calculator--An Inexpensive Teaching Machine. MATYC Journal 12: 215-219; Fall 1978.

A program is presented which enables a programmable calculator to become a device to check the arithmetic computational skills of students.

Hartman, Elliott. Breaking Through the Googol Barrier. MATYC Journal 12: 208; Fall 1978.

An example is given for expressing $y^x$ in scientific notation when the results exceed the calculator display.

King, Ronald Scott. Presentation of Hierarchical Clustering Techniques in the Two Year College Mathematics Classroom. MATYC Journal 12: 97-101; Spring 1978.

A grouping procedure which systematically combines objects to satisfy a criterion specified by the investigator and groups those objects that are most alike first is discussed. Two such methods that can be easily demonstrated with the aid of calculators are presented.

Kissler, Gary D.; Dreese, Curtis W.; and Kissler, Janice M. The Effects of Student Calculator Use upon Measures, of Numerical Aptitude and Business Statistics. February 1978. ERIC: SE 025 086.

In the first study, 127 college sophomores in a business course were randomly assigned to one of four groups and given a 40-item aptitude scale, with an 8-week interval before a second testing. Students using calculators performed consistently better and sometimes significantly better than students not using calculators. In the second study, 266 sophomores in a business statistics course were tested as they used or did not use calculators. In every instance, the group using calculators received a higher score; however, significant differences were found on only three of five exams.

Koop, Janice Baker. A Description of the Effects of the Use of Calculators in the Community College Arithmetic Class. (University of Colorado, 1978.) Dissertation Abstracts International, in press.

Six classes (N = 150 community college students) enrolled in one of three time periods, and were then randomly assigned to treatments for nine weeks. Students recorded time spent on homework; instructors detailed time spent on each topic and activity, with one group using calculators for all class, homework, and testing activities. No significant differences were found between groups on problem solving or computation. A treatment-by-age interaction was found for problem solving and total test, favoring younger students. No significant difference in attitudes toward mathematics or self-confidence were found, but the calculator group had significantly more positive attitudes toward calculators. No significant differences were found on the retention test (six weeks later). The calculator group spent less time doing homework and going over homework in class, and 50 percent more time on problem solving.

Maor, Eli, The History of Pi on the Pocket Calculator. Journal of College Science Teaching 6: 97-99; November 1976.

Historical information on pi is presented in the context of a classroom experience using calculators to calculate pi.

Peckham, Herbert D. and Weir, Maurice D. Introduction to the TI-59 Programmable Calculator. Calculators/Computers 2: 52-57; September/October 1978.

Activities designed to familarize (calculus) students with the use of the TI-59 are presented.

Reiland, Robert J. A Realistic Model Rocket Program for a Small Programmable Calculator. Calculators/Computers 2: 72-74; September/October 1978.

A program for the prediction of the altitude achievable by a model rocket is given.

Roberts, Dennis M.; Seaman, Dennis; and Lerner, Jackie. Maximizing Effects of Calculators: A Study Varying Calculation Procedures, Difficulty of Tasks and Working Instructions. Calculators/Computers 2: 60-62; May 1978.

The study compared the differences between "the best computational method" (a calculator with sophisticated features) with "the most tedious one" (hand work). Sixty-four students (from an introductory statistics course) were randomly assigned to calculator or hand groups. All worked one set each of problems under directions to work as fast as possible and as

accurately as possible. The number of correct answers in the calculator group was more than double that of the hand group. Easy problems were solved correctly more often than hard problems, with a considerable drop in performance on hard problems in the hand group. It took the hand group about six times longer to work the problems. The calculator group was over 15 times more efficient. The work-fast and work-accurately directions had no significant effect on performance. Attitude comparisons favored the calculator.

Smith, Buddy Lee. A Study of the Effectiveness of the Use of the Electronic Calculators in Teaching the Simplex Method to Business and Economics Majors. (North Texas State University, 1977.) Dissertation Abstracts International 38A: 3986; January 1978.

Attitudes toward mathematics and achievement in mathematics in groups which used or did not use calculators in the classroom were studied. Sixty-nine students in two sections of a one-semester business and economics course were randomly selected. Little difference in achievement or attitude was found between users and non-users, sexes, or aptitude levels.

Snover, Stephen L. and Spikell, Mark A. The Role of Programmable Calculators and Computers in Mathematical Proofs. Mathematics Teacher 71: 745-750; December 1978.

Since numerous possibilities can be examined in a relatively short period of time, calculators and computers are powerful data-gathering instruments. How they can be used in proofs is explored with a simple rpoblem from number theory.

Steuer, Michael. Banking on Your Calculator. MATYC Journal 12: 193-194; Fall 1978.

Using a calculator to compound interest is presented.

Waits, Bert K. Classroom Applications of the Inexpensive Hand-Held Calculator. Two-Year College Mathematics Journal 9: 162-16; June 1978.

A calculator is used to explore several topics suitable for beginning college students, particularly students in developmental or beginning algebra courses. Compound interest, work with exponents, and limits are included in the examples cited

Calculus Taught with Calculators. Machine Design 50: 4; February 1978.

An NSF-sponsored project, in which calculators are used in calculus at Ohio State, is described.

1978 Buying Guide to Electronic Calculators. MATYC Journal 12: 229-235; Fall 1978.

This is an excerpt from the report by Buyers Laboratory, noting features, programming capability, and other factors for a wide variety of calculators.

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This publication was prepared pursuant to a contract with the National Institute of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their judgment in professional and technical matters. Points of view or opinions do not, therefore, necessarily represent official National Institute of Education position or policy.

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Reference Bulletin No. 23
April 1979

**References on Instructional Activities, Research Reports, and Other Topics Related to Calculator Use, K-12**

In this bulletin, references are grouped to aid you in locating materials which you might find particularly useful.

## ACTIVITIES FOR STUDENTS

Aviv, Cherie Adler. Pattern Gazing. Mathematics Teacher 72: 39-43; January 1979. Worksheets on pattern searches are provided.

Billings, Karen and Moursund, David. Problem Solving. Calculators/Computers 2: 73-94; November-December 1978. Chapter 2 from Problem Solving with Calculators is given. How to tackle a variety of problems is explained, using a worksheet-like format.

Dubisch, Roy and Hood, Vernon R. Basic Mathematics with Hand-held Calculator: A Work-Text. Menlo Park, California: Benjamin/Cummings Publishing Company, 1979. This worktext is for students at either secondary or college level.

Goodson, Bobby. Let's Put the Calculators Where They Belong. Calculators/Computers 2: 20-22; November-December 1978. Use of the calculator in work with square roots, geometry, factoring, and other junior high topics is discussed. A worksheet on finding a square root and a crossword puzzle developed by a student are given.

Goodson, Bobby. Calculator Resource Review. Calculators/Computers 2: 32-33; November-December 1978. Some books of calculator activities which the author considers particularly useful for junior high classes are cited.

Hiatt, Arthur A. Basic Skills: What Are They? Mathematics Teacher 72: 141-144; February 1979. With the calculator, students' mathematical thinking should be improved as they handle non-routine problems in which a number of accurate calculations are necessary. Specific examples involving use of the calculator in applying process skills are given.

Jurgensen, Marlinde. Measuring Triangles. Calculators/Computers 2: 50-52; November-December 1978. A teaching plan using calculators with the Pythagorean Theorem is presented, with a worksheet on measuring triangles.

Keller, Clifton. Using Tables to Teach Mathematics. Mathematics Teacher 71: 655-656; November 1978. Use of calculators is suggested as an aid in performing the calculations involved in pattern searches.

Kerr, Steven D. Who is Quickest with Mind and Fingers? Mathematics Teacher 72: 123-126; February 1979. A "thinking person's calculator race" is described, with sample questions.

Ockenga, Earl and Duea, Joan. Ideas. Arithmetic Teacher 26: 28-32; January 1979. Games for addition, subtraction, multiplication, and division are presented, with the objective of providing practice in estimation.

Olson, Melfried. Using Calculators to Stimulate Conjectures and Algebraic Proofs. Mathematics Teacher 72: 288-289; April 1979. Three examples are given that can be used to stimulate conjectures and that lend themselves to an algebraic proof. The calculator can enable students to test cases which would have been fruitless, if not impossible, without the calculator.

Reys, Robert E. et al. Keystrokes: Calculator Activities for Young Students: Addition and Subtraction. Palo Alto, California: Creative Publications, Inc., 1979. This workbook contains a variety of activities in which calculator use is integrated with mathematical instruction.

Russakoff, Andrew. Calculator Calculations. Mathematics Teacher 72: 188; March 1979. Using the calculator for graphing the relations for equations like $x^a + y^a = 5^a$ is presented.

Scott, Douglas E. What Day of the Week . . .? Calculators/Computers 2: 26-29; November-December 1978. An algorithm for determining the day of the week for any date is given for calculators (a BASIC program for computers is also included).

Snover, Stephen L. and Spikell, Mark A. How to Program Your Programmable Calculator. Englewood Cliffs, New Jersey: Prentice-Hall, 1979. Procedures for programming calculators are explained in detail, with many specific examples, for two types of calculator logic.

Wavrik, John A Short Presentation in "Computer Literacy" using Programmable Calculators lculators/Computers 2: 9-11; November-December 1978. This article outlines a one-lesson "computer literacy" presentation for grades 5 and 6 using the HP-25 programmable calculator. Following a ten-minute introduction in which nine points are cited, students are given experience entering and running programs.

Wavrik, John J. Programmable Calculators for Elementary Schools. Calculators/Computers 2: 53-55; November-December 1978. A lesson on simple programming for students in grades 4-6 is presented, with several programs included.

MORE MATERIALS . . . FROM PROJECTS (* indicates contact person)

Columbus Calculator Project (ESEA Title IV-C). Catherine Gilbreath, James Huber*, and Alberta Myers, Columbus (Ohio) Public Schools, 1978. Modules for each of these topics have been developed: Know Your Calculator, Basic Facts, Place Value, Decimal Computation, Properties, Rounding, Estimation, and Applications.

Calculating Devices. Don Fritz, L.B.J. High School, Austin, Texas, 1975. This is a one-quarter course for remedial ninth-grade students who have not mastered the fundamental operations. The course has been in the curriculum for five years.

Iowa Problem-Solving Project (ESEA Title IV-C). Joan Duea, George Immerzeel*, Earl Ockenga, John Tarr, and Jack Wilkinson, Price Laboratory School, University of Northern Iowa, Cedar Falls, 1978. This project focused on developing materials to improve the mathematical problem-solving abilities of students in grades 5-8, using calculators. The materials are available in classroom sets for experimentation.

Rising, Gerald R.*; Krist, Betty J.; Roesch, Carl; and Jewell, Wallace. Using Calculators in Mathematics. National Institute of Education Contract No. 400-78-0013. State University of New York at Buffalo, 1978. This preliminary set of materials incorporates the use of programmable calculators in the standard mathematics curriculum in grades 11 and 12 (following the New York State syllabus). Chapters 1 through 7 are available to those especially interested in trying them out.

Calculator Inservice Kit. Prepared by Mathematics Division, North Carolina State Department of Public Instruction, 1978. In this notebook kit are transparency masters, calculator games, calculator activity cards for grades 5 through 9, and a calculator problem card deck for teachers. (For information, contact George Immerzeel, Iowa Problem-Solving Project, page 2.)

## RESEARCH REPORTS (WHICH MAY ALSO CONTAIN IDEAS FOR INSTRUCTION)

Blume, Glendon W. The Calculator's Effect on Children's Solution Processes. In Research Reporting Sessions, NCTM 57th Annual Meeting. Columbus: ERIC/SMEAC, March 1979. Pp. 59-61. In this exploratory study, the 21 seventh-grade pre-algebra students tended to use different solution methods when working with calculators than when restricted to use of paper and pencil.

Downes, John P.; Jensen, Rosalie S.; and Johnson, Hiram D. 76 Questions: A Synthesis of the Research on Teaching and Learning Mathematics. Atlanta: Georgia Department of Education, December 1977. ERIC: SE 025 422. One brief section considers research on calculators.

Gallery, Michael Edward. Teaching Calculator Use and Checking Account Skills to the Mildly Handicapped. (Utah State University, 1978.) Dissertation Abstracts International 39A: 2866; November 1978. Two "packages" on calculator skills and on checking account skills were evaluated with 38 students from six high schools and two junior high schools. Eighteen students received instruction on the packages, while 20 students were in the control group. The difference between group posttest means for both packages significantly favored the experimental group. However, the mastery criterion was not achieved on either package.

Jamski, William D. The Effect of Calculators on Achievement. MATYC Journal 13: 52-56; Winter 1979. This is a report of Jamski's dissertation research (completed in 1976) with seventh graders. He concludes that the calculator appears likely to be successful with some topics, such as fraction-decimal conversion, but not with others.

Jewell, Wallace F., Jr. Hand Calculators in Secondary Education: Evaluation, Analysis and Direction. Unpublished doctoral dissertation, State University of New York at Buffalo, 1979. The purpose of this study was to analyze and evaluate present hand-held calculator uses and materials and propose possible directions for their utilization in the near future. Also included is an analysis of the usual high school mathematics curriculum of elementary algebra, geometry, intermediate algebra-trigonometry, and elementary functions with regard to calculator implementation.

Kobrin, Beverly. The Hand-held Calculator: Effects on Intermediate Grade Mathematics Achievement. (Brigham Young University, 1978.) Dissertation Abstracts International 39A: 3354; December 1978. In grades 4-6, the experimental group ($n = 75$) used calculators for a year at least one hour per week on selected calculator activities, while the control group ($n = 141$) did not use calculators. No significant differences in achievement were found between the two groups.

**Kolpas, Sidney J. The Use of Electronic Calculators as In-Class Instructional Aids in a Ninth-Grade Arithmetic Program. Unpublished doctoral dissertation, University of Southern California, 1978.** Eighty ninth-grade low- and underachievers in four arithmetic classes participated in this 20-week study. The two experimental classes used calculators as instructional aids and as the sole solution-source for 50% or for 75% of each in-class assignment, while control classes (from another school) did not use calculators. The Comprehensive Test of Basic Skills was given as the pre- and posttest, and a researcher-constructed test was completed twice (first by hand, then with calculators to correct). No significant differences were found on the standardized test; significant differences on the researcher's test favored the experimental groups both with and without calculators.

**Lunder, Dennis A. The Impact of the Calculator on Test Anxiety for High School Consumer Mathematics Students. Unpublished doctoral dissertation, University of Denver, 1978.** Consumer mathematics students (n = 159) in grades 9-12 in three schools were randomly scheduled into two experimental groups (using calculators) or two control groups (not using calculators). One experimental and one control group used calculators on the posttest, while the other two groups did not. Using calculators for instruction and testing resulted in higher scores than not using calculators for instruction but using them on the test. Test anxiety was also explored; use of the calculator did not significantly reduce anxiety.

**Mason, Marguerite. The Hand-held Calculator in the Elementary School, An Exploratory Study of Two Issues: Dependency and the Effect on the Problem-solving Process. In Research Reporting Sessions, NCTM 57th Annual Meeting. Columbus: ERIC/SMEAC, March 1979. Pp. 49-51.** Two pairs of students, matched on mathematics pretests, were chosen at each grade level from 2-6. One student from each pair was from an experimental class which used calculators, and the other from the control class which did not use calculators. Each student was given a set of computational exercises and five word problems to solve in once-a-month interviews. All students had a calculator available. The mode used to solve exercises and problems was recorded. There was no evidence that students became calculator dependent. Follow-up tests showed that it was advantageous to have calculators available for certain types of exercises (such as division for third graders).

**Moser, James M. The Effect of Calculator Supplemented Instruction on the Arithmetic Achievement of Second and Third Graders. In Research Reporting Sessions, NCTM 57th Annual Meeting. Columbus: ERIC/SMEAC, March 1979. Pp. 29-31.** Participants were children in grades 2 and 3 in eight classes in two schools. One school was implementing a traditional curriculum and the other used the DMP program. The calculator was used with the ongoing programs; teachers were given suggestions on how the calculator could be used, and kept logs which were validated by unannounced visitations. Amount of use of calculators ranged from 36% to 79% of instructional days, and from 16% to 48% of instructional minutes.

**Shin, Joseph. A Survey on the Attitude of Schoolchildren Towards the Use of Calculators in Schools. Calculators/Computers 2: 39-41; November-December 1978.** A questionnaire given to four classes (n = 152) of fourth formers in a Hong Kong middle school is presented. More than 77% of the children had some experience using calculators; 60% of them or their families owned a calculator. Over 76% thought that calculators should be used on tests. Other findings are also given, and the value of calculator use is discussed.

Suydam, Marilyn N. (Editor). Investigations with Calculators: Abstracts and Critical Analyses of Research. Columbus: Calculator Information Center, January 1979. This document contains expanded abstracts of 36 research reports in which the use of calculators was explored, with comments on each report by the abstractor.

Szetela, Walter. Hand-Held Calculators and the Learning of Trigonometric Ratios. Journal for Research in Mathematics Education 10: 111-118; March 1979. The investigator and the regular teacher used specially designed materials for teaching trigonometric ratios to 131 students in grades 9 and 10 randomly assigned to groups using calculator-based instruction or not using calculators for 13 days. Students built their own short trigonometric tables using measurements of specially constructed right triangles. On a quiz one week before the final test, the calculator groups scored significantly higher than the non-calculator groups. There were no significant differences on the final test or in attitude toward learning ratios.

Ward, Dennis Elliott. The Effect of the Electronic Calculator on Problem-Solving Achievement and Attitudes Toward Mathematics of General Mathematics Students. (University of Southern California, 1978.) Dissertation Abstracts International 39A: 4038; January 1979. In the first semester of 1977-78, 92 general mathematics students were randomly assigned to two experimental classes (using calculators) and two control classes (not using calculators). No significant differences in problem-solving achievement or attitudes were found; no gender effect was found. Better readers tended to score higher on problem solving both with and without calculators.

Wheatley, Charlotte L. The Effect of Calculator Use on the Problem Solving Strategies of Elementary School Pupils. In Research Reporting Sessions, NCTM 57th Annual Meeting. Columbus: ERIC/SMEAC, March 1979. Pp. 25-27. Fifty fifth graders were involved in this study; 25 were from classes that had used calculators for three months, while the other 25 were randomly selected from two classes with no previous in-class calculator experience. Each student responded to five selected problems during 40-minute sessions which were tape-recorded, transcribed, and coded. The coding data were tallied to obtain frequencies of strategy use and performance scores. The two groups did not differ significantly on the range of processes used, time to solution, or performance.

Williams, David E. The Effect of the Use of the Mini-Calculator and an Associated Curriculum Supplement on Computational Skills and Attitudes Toward Arithmetic of Ninth-Grade Non-College Bound Students. Unpublished doctoral dissertation, Temple University, 1978. This year-long study was conducted in five junior high schools in Philadelphia, with three teachers each teaching one class using calculators with the regular general mathematics curriculum, one class using the regular curriculum with calculators and supplementary calculator materials, and a comparison class not using calculators. Calculators were not used on the pre- or posttest (California Achievement Test). No significant differences were found in computational skill, while attitude differences favored the calculator groups.

Williams, S. Irene and Jones, Chancey O. A Survey of the Use of Hand-Held Calculators in Advanced Placement Calculus Courses. Princeton, New Jersey: Educational Testing Service, 1979. The questionnaire was sent to mathematics department chairpersons at the 2042 secondary schools that had five or more students taking an Advanced Placement examination in May 1977; returns were received from 1547 schools, with 1403 scorable. About 89% indicated they permitted some use of calculators in calculus courses. Slightly more than 10% had modified their courses to include special techniques particularly suited to the use of the calculator. In only 20% of

the schools were calculators supplied by the school districts. An overwhelming majority think that student performance (on AP examinations) would not significantly be affected if calculator use was permitted.

## MISCELLANEOUS ISSUES AND CONCERNS

D'Ambrosio, Ubiratan. Issues Arising on the Use of Hand-held Calculators in Schools. International Journal of Mathematical Education in Science and Technology 9: 383-388; 1978. The use of calculators is considered from pedagogical and sociological viewpoints. The effects of adoption of calculators in developing countries and for deprived minorities is noted and the role of calculators in problem solving is discussed.

Free, John. Pocket Calculators for More Than Math. Popular Science 214: 22ff; April 1979. Some features and some weaknesses of liquid display calculators are discussed.

Huff, Darrell. Calcu-Letter. Popular Science 214: 58; January 1979; 214: 23; March 1979. This bi-monthly column continues to present problems and discuss points related to calculators.

Usiskin, Zalman P. The Future of Fractions. Arithmetic Teacher 27: 18-20; January 1979. The effect of calculator use on the teaching of fractions is among the factors discussed.

Calculators. Business Education Forum 33: 28-31; January 1979. Various types of calculators available currently are described briefly.

Flow Charts and Calculators. In General High School Mathematics. Albany, New York: State Education Department, August 1978. Pp. 58-64. ERIC: SE 025 300. The use of calculators is encouraged, along with the use of flow charts. Reasons for using calculators are given.

* Additional manuscripts have been received from Hutton and from Shumway et al. (on research) and from Snover and Spikell and from Szetela (on instructional activities). These and other references from newsletters of NCTM Affiliated Groups and from non-US journals will be listed, along with references from Calculator Information Center bulletins, in a forthcoming publication, Calculators: A Categorized Compilation of References (Marilyn N. Suydam, editor), which will be available later in the year from ERIC.

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This bulletin (and all other reference bulletins from the Center) was prepared by Marilyn N. Suydam, The Ohio State University -- Director of the Calculator Information Center.

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Reference Bulletin No. 24
April 1979

## References on Instructional Use and Research with Calculators at the College and Other Post-Secondary Levels

Addis, G. H. The Use of Programmable Calculators in the Teaching of Economics, Part II. Economics 14: 50-58; Summer 1978. The use of programmable calculators to perform classroom controlled experiments on economic models is described.

* Ayers, Sharon Whitton. The Effects of Situational Problem-solving and Electronic Calculating Instruments in a College Level Introductory Statistics Course. In Research Reporting Sessions, NCTM 57th Annual Meeting. Columbus: ERIC/SMEAC, March 1979. Pp. 57-58. The author's 1976 dissertation is abstracted.

Briggs, A. G. The Rydberg Constant--A Hand-Calculator Exercise. Physics Teacher 16: 291-292; May 1978. Described is a hand-held calculator exercise for computing the Rydberg Constant accurately.

Coons, David F. A Concise Method for Computing Normal Curve Areas Using a Calculator. Educational and Psychological Measurement 38: 653-655; Fall 1978. A concise method for computing areas under the normal curve using only functions typically found on desk and hand calculators is given. One version of this method will give three-decimal-place accuracy; a second, simpler version gives accuracy to two places.

Eisberg, Robert. Programmable Pocket Calculators in College Science Teaching. Journal of College Science Teaching 7: 305; May 1978. The use of programmable calculators to solve second-order differential equations is described in an article which consists of examples selected by the author from his 1976 book.

* Gooden, Curtis Lee. Some Effects of Using Minicalculators in an Arithmetic Course on the Attitude Towards Mathematics and the Mathematics Achievement of Community College Students. (Kent State University, 1978.) Dissertation Abstracts International 39A: 2800-2801; November 1978. Three groups (n = 220) in nine sections of College Arithmetic in a community college were involved in the study during Spring 1977. The control group did not use calculators; one experimental group was allowed to use them "any time they wished"; the other experimental group was also assigned problems which required use of calculators approximately 85% of the time. Use of the calculator was found to be no more effective than paper-and-pencil techniques in increasing mathematical achievement and attitudes, but no loss in proficiency with paper-and-pencil skills was found when calculators had been used.

Hughes, B. G. and Bundschuh, J. E. The Use of a Hand-Held Programmable Calculator in Evaluating Freshman Experiments. Journal of Chemical Education 55: 336-337; May 1978. The use of a programmable calculator for evaluating a student's performance on a quantitative laboratory experiment is presented.

Jewell, Wallace F., Jr. Teaching Remedial Mathematics with Calculators. MATYC Journal 13: 41-46; Winter 1979. A basic mathematics review course using the hand calculator as a complete substitute for paper-and-pencil calculation is described.

Marshall, John and Hussey, Greg. Light-Activated Timer Made From a Pocket Calculator. Physics Teacher 16: 323-324; May 1978. Described are procedures and equipment needed to modify a calculator timer to control it photoelectrically.

* Mcanelly, James Robert. A Study of the Mathematical Competencies Considered Important by Supervisors in Large Retail Firms in the Metropolitan Area of Chicago. (Northern Illinois University, 1978.) Dissertation Abstracts International 39A: 3314-3315; December 1978. Supervisors in large retail firms rated the competency in the proficient use of hand-held calculators and/or calculating machines as most important.

* McLeod, Douglas B. and Adams, Verna M. Aptitude-treatment Interaction in Mathematics Instruction Using Calculators. April 1979. ERIC: SE 026 827. Students in three mathematics classes for prospective elementary teachers were assessed on two aptitudes, field independence and general reasoning, and randomly assigned to either an expository (n = 24) or a discovery (n = 23) treatment. The instruction involved errors in measurement and calculations with approximate data. A significant interaction was found with general reasoning on the retention test, as predicted. There were no interactions with field independence.

Schultz, James, E. and Waits, Bert K. A New Look at Some Old Problems in Light of the Hand Calculator. Two-Year College Mathematics Journal 10: 20-27; January 1979. The calculator is used to solve equations which may be difficult or impossible to solve by standard methods. Problems involving ladders, car loan payments, and the hungry goat are discussed.

Snover, Stephen L. and Spikell, Mark A. Because of Programmable Calculators, Why Avoid These Problems Any Longer? January 1979. ERIC: SE 026 857. Several examples of types of problems accessible to students who have programmable calculators are given. Finding limits, evaluating and calculating infinite series, computing variable length products, searching for data, and developing proofs are among the examples.

Snover, Stephen L. and Spikell, Mark A. How to Program Your Programmable Calculator. Englewood Cliffs, New Jersey: Prentice-Hall, 1979. Procedures for programming calculators are explained in detail, with many specific examples, for two types of calculator logic.

Spero, Samuel W. Computers and Calculators: A Strategy for Combined Usage in Trigonometry. 1977. ERIC: ED 156 208. The strategy was used to incorporate the computer and the hand calculator into trigonometry courses at an Ohio community college. The computer was used to generate different problem sets for individuals; students then used calculators to complete the problems.

Zimmerman, Mark. Random Numbers and Pocket Calculators. Calculators/Computers 2: 42-43; November-December 1978. A procedure for generating random numbers with an HP-55 programmable calculator is presented.

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This bulletin (an all other reference bulletins from the Center) was prepared by Marilyn N. Suydam, The Ohio State University -- Director of the Calculator Information Center. This publication was prepared pursuant to a contract with the National Institute of Education, U.S. Department of Health, Education, and Welfare.
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